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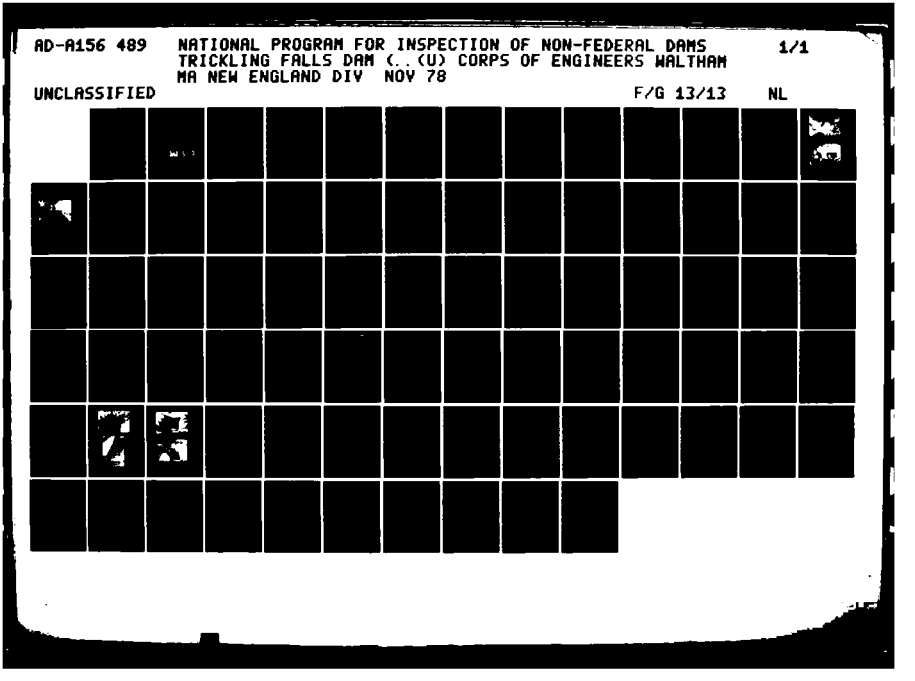

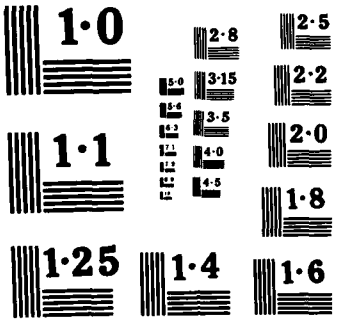


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(2)

MERRIMACK RIVER BASIN
EAST KINGSTON, NEW HAMPSHIRE

# TRICKLING FALLS DAM

NH 00440

NHWRB 72.01

# PHASE I INSPECTION REPORT
# NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS. 02154

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Merrimack River Basin
East Kingston, New Hampshire
Powwow River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The dam is a 250 ft. long earthfill structure which incorporates a 34 ft. long concrete gravity ogee spillway and a three bay sluiceway with stoplogs. It is intermediate in size with a low hazard potential. The test flood is between the 100 yr. flood and ½ the PMF. Further hydrological and hydraulic studies of the spillway adequacy should be made.The dam is in fair condition at the present time.

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REPLY TO
ATTENTION OF:

NEDED

JAN 2 3 1975

Honorable Hugh J. Gallen
Governor of the State of New Hampshire
State House
Concord, New Hampshire 03301

Dear Governor Gallen:

I am forwarding to you a copy of the Trickling Falls Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Water Resources Board, the cooperating agency for the State of New Hampshire. In addition, a copy of the report has also been furnished the owner, New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301, ATTN: Mr. George M. McGee, Sr., Chairman.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Water Resources Board for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

TRICKLING FALLS DAM
NH 00440

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MERRIMACK RIVER BASIN
EAST KINGSTON, NEW HAMPSHIRE

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

# NATIONAL DAM INSPECTION PROGRAM

## PHASE I REPORT

| | |
|---|---|
| Identification No.: | NH 00440 |
| NHWRB No.: | 72.01 |
| Name of Dam: | TRICKLING FALLS DAM |
| Town: | East Kingston |
| County and State: | Rockingham County, New Hampshire |
| Stream: | Powwow River |
| Date of Inspection: | September 21, 1978 |

## BRIEF ASSESSMENT

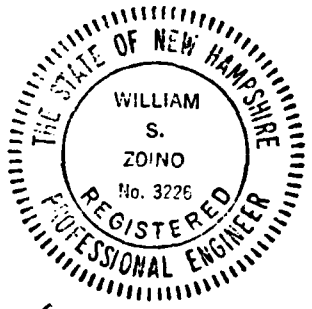
The Trickling Falls Dam is a 250 foot long earthfill structure which incorporates a 34 foot long, concrete gravity ogee spillway and a three bay sluiceway with stoplogs. The dam, which is owned by the New Hampshire Water Resources Board (NHWRB), has a maximum height of approximately 12 feet. While an earthfill dam of some type has existed at the site since before 1940, major alterations in 1940 and 1962, both carried out by the NHWRB, have resulted in the structure's present configuration.

The dam, which lies on the Powwow River, is used primarily to control the level of Powwow Pond for recreational purposes. Some flood control functions are also served, however. The 30.6 square mile drainage area consists of flat to steeply sloping forest. The dam's maximum impoundment of approximately 1700 acre-feet places it in the INTERMEDIATE size category, while the lack of any significant downstream hazard results in a LOW hazard potential classification.

Based on the size and hazard potential classification and in accordance with the Corps' guidelines, the Test Flood (TF) is between the 100 year flood and one half the Probable Maximum Flood (PMF). The selected TF inflow of 7500 cfs results in a peak discharge at the dam of 6300 cfs. Since the maximum capacity of the dam prior to overtopping is only approximately 2200 cfs, the TF would overtop the dam by more than 2 feet. For this reason, further hydrologic studies of the spillway adequacy should be made.

The dam is in FAIR condition at the present time and requires considerable routine maintenance. Recommended remedial measures include repair of erosion on the embankment, removal of all trees and brush from the embankment, monitoring of two small seepages, repair of deteriorated concrete surfaces and joints, repair of a concrete wall, repair of safety railing, clearing or trimming of trees and other potential obstructions in and around the approach and downstream channels, and training of local officials in dam operation to decrease response time in an emergency.

The improvements and recommendation outlined above should be implemented within two years of receipt of the Phase I Inspection Report by the owner. In light of the dam's FAIR condition, periodic technical inspections should be scheduled every two years.




William S. Zoino
New Hampshire Registration 3226

Robert Minutoli
Massachusetts Registration 29165

This Phase I Inspection Report on Trickling Falls Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Richard F. Doherty

RICHARD F. DOHERTY, MEMBER
Water Control Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph A. McElroy

JOSEPH A. MCELROY, CHAIRMAN
Chief, NED Materials Testing Lab.
Foundations & Materials Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

## PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

TABLE OF CONTENTS


| | | Page |
|---|---|---|
| LETTER OF TRANSMITTAL | | |
| BRIEF ASSESSMENT | | |
| REVIEW BOARD SIGNATURE SHEET | | |
| PREFACE | | iv |
| TABLE OF CONTENTS | | v |
| OVERVIEW PHOTOS | | vii |
| LOCATION MAP | | ix |
| SECTION 1 - PROJECT INFORMATION | | |
| 1.1 | General | 1-1 |
| 1.2 | Description of Project | 1-2 |
| 1.3 | Pertinent Data | 1-4 |
| SECTION 2 - ENGINEERING DATA | | |
| 2.1 | Design Records | 2-1 |
| 2.2 | Construction Records | 2-1 |
| 2.3 | Operational Records | 2-1 |
| 2.4 | Evaluation of Data | 2-1 |
| SECTION 3 - VISUAL INSPECTION | | |
| 3.1 | Findings | 3-1 |
| 3.2 | Evaluation | 3-5 |
| SECTION 4 - OPERATIONAL PROCEDURES | | |
| 4.1 | Procedures | 4-1 |
| 4.2 | Maintenance of Dam | 4-1 |
| 4.3 | Maintenance of Operating Facilities | 4-1 |
| 4.4 | Description of Any Warning System in Effect | 4-1 |
| 4.5 | Evaluation | 4-1 |

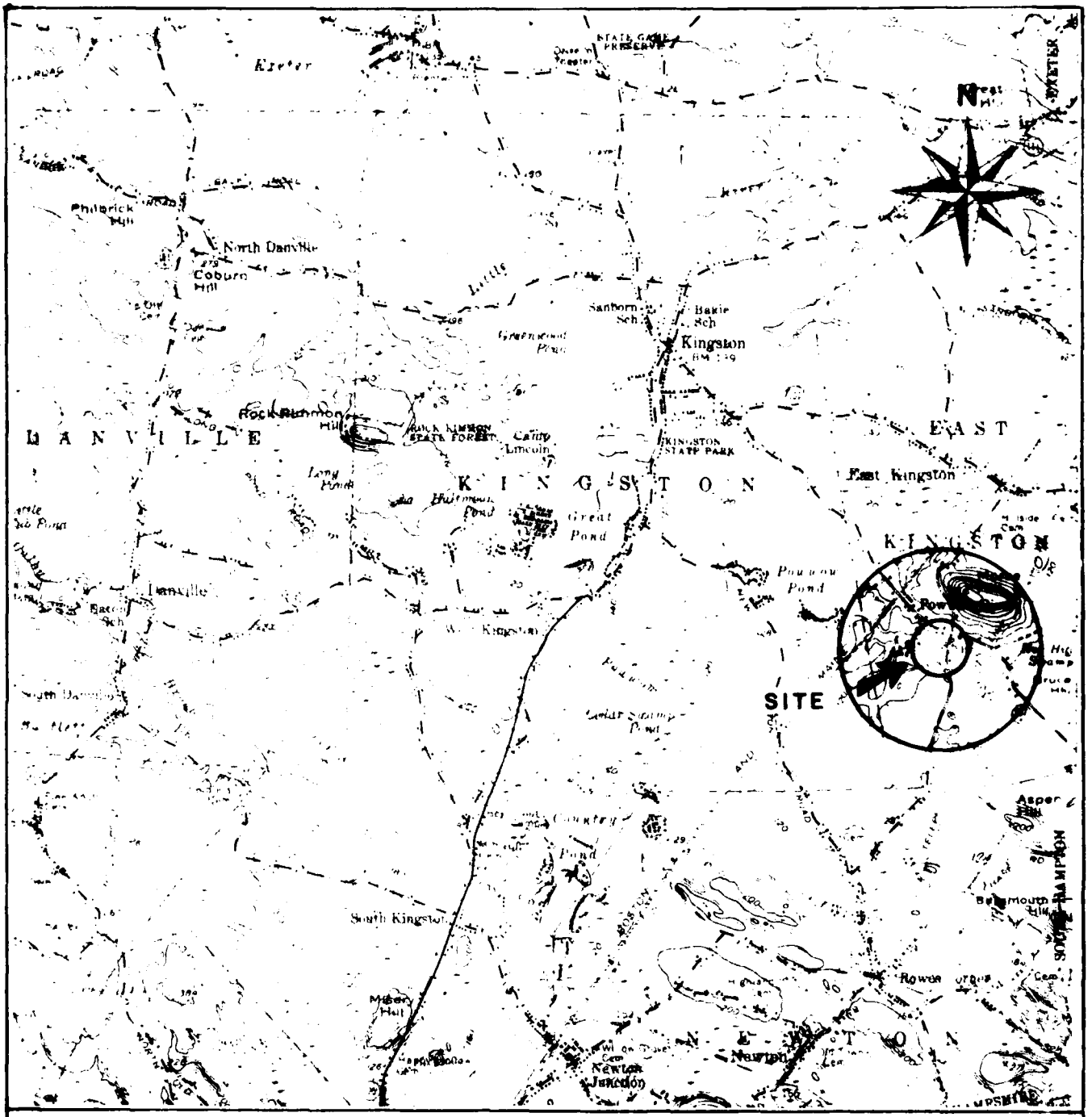
Table of Contents - cont.


| | | Page |
|---|---|---|
| SECTION 5 - HYDRAULIC/HYDROLOGIC | | |
| 5.1 | Evaluation of Feature | 5-1 |
| 5.2 | Hydraulic/Hydrologic Evaluation | 5-3 |
| 5.3 | Downstream Dam Failure Hazard Estimate | 5-4 |
| SECTION 6 - STRUCTURAL STABILITY | | |
| 6.1 | Evaluation of Structural Stability | 6-1 |
| SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES | | |
| 7.1 | Dam Assessment | 7-1 |
| 7.2 | Recommendations | 7-1 |
| 7.3 | Remedial Measures | 7-1 |
| APPENDICES | | |
| APPENDIX A - VISUAL INSPECTION CHECKLIST | | A-1 |
| APPENDIX B - FIGURES AND PERTINENT RECORDS | | B-1 |
| APPENDIX C - PHOTOGRAPHS | | C-1 |
| APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS | | D-1 |
| APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS | | E-1 |

Overview of dam from left side
downstream (Sept. 21, 1978)

Overview of dam from right side
downstream (May 25, 1978)

Overview of dam from left side upstream
(Sept. 21, 1978)




- SCALE -

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FROM: USGS HAVERHILL, MA QUADRANGLE MAP

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| GOLDBERG, ZOINO, DUNNICLIFF & ASSOC, INC.<br>GEOTECHNICAL CONSULTANTS<br>NEWTON UPPER FALLS, MASS. | U.S. ARMY ENGINEER DIV. NEW ENGLAND<br>CORPS OF ENGINEERS<br>WALTHAM, MASS. |

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

# LOCUS PLAN

FILE No. 2067

TRICKLING FALLS DAM — NEW HAMPSHIRE

| | |
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| SCALE | AS NOTED |
| DATE | SEPT 1978 |

# PHASE I INSPECTION REPORT
# TRICKLING FALLS DAM
# SECTION 1
# PROJECT INFORMATION

## 1.1 General

### (a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a national program of dam inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hampshire. Authorization and notice to proceed was issued to GZD under a letter of August 22, 1978 from Colonel Ralph T. Garver, Corps of Engineers. Contract No. DACW 33-78-C-0303 has been assigned by the Corps of Engineers for this work.

### (b) Purpose

(1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

(2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

(3) Update, verify and complete the National Inventory of Dams.

### (c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dam.

## 1.2 Description of Project

### (a) Location

The Trickling Falls Dam lies on the Powwow River near the intersection of Route 107A and the road connecting Route 107A with Route 108. This junction is approximately 2.8 miles southeast of the town of Kingston. The portion of the USGS Haverhill quadrangle presented on page ix shows this locus. Figure 1 of Appendix B shows a site plan developed from the map and the visual inspection.

### (b) Description of Dam and Appurtenances

This dam is a 250 foot long earthfill structure which incorporates a 34 foot wide concrete ogee spillway and a three bay sluiceway equipped with stoplogs (Pages B-3 through B-5). Two of the sluiceway bays are 5 feet wide while the third is 5.5 feet wide. The inverts of the two leftmost sluiceways are 2 feet below the spillway crest while the invert of the third is 7.6 feet below the crest. A concrete walkway spans over the sluiceways. The maximum height of the embankments and the concrete portions of the dam is approximately 12.0 feet. A brass plug at El. 114 (MSL) on the upstream face of the sluiceway structure serves as a reference point for water level readings.

Ancillary portions of the outlet structure consist of two endwalls, the left one having a $90^{o}$ wingwall upstream of the sluiceway bays and a $90^{o}$ return located at the downstream end of the structure. Construction drawings dated January 1940 indicate that a cut-off wall, located approximately 8 feet upstream of the stoplog slots, penetrates approximately 1 foot below grade 8 feet into the left embankment. The right endwall, which is approximately 45 feet long and which is normal to the spillway axis, also contains a monolithically cast cut-off wall located normal to the endwall and in line with the spillway axis.

### (c) Size Classification

The dam's maximum impoundment of 1700 acre-feet falls within the 1000 to 50,000 acre-feet range which defines the INTERMEDIATE size category as defined in the "Recommended Guidelines."

(d) Hazard Potential Classification

With the possible exception of one house, there is no significant development within the area which would be affected by a failure of the dam. The only probable effect on this house would be basement flooding since the first floor is above the 6.4 feet flooding depth. For this reason, a hazard potential classification of LOW is assigned.

(e) Ownership

The NHWRB owns this dam. Key officials are Chairman George McGee, Chief Engineer Vernon Knowlton, Assistant Chief Engineer Donald Rapoza and Staff Engineers Pattu Kesavan and Gary Kerr. The Board's telephone number is (603) 271-3406 and it can also be reached through the State Capital operator at (603) 271-1110. The Merri-Mack Valley Power and Building Company turned the dam over to the state in 1940.

(f) Operator

The NHWRB has permanent dam tenders who simultaneously cover all dams owned by the state. The operators can be reached through the Board's engineers, who direct all dam operations.

(g) Purpose of Dam

The primary purpose of the dam is to maintain the level of Powwow Pond for recreational use. The dam also provides some flood control benefits.

(h) Design and Construction History

The Merrimack Valley Power and Building Company had some type of earthfill dam at the site prior to 1940 (Pages B-6 and B-7). With the advent of state ownership in 1940, the dam was significantly modified by the construction of a concrete spillway and sluiceway designed by Roland S. Burlingame of the NHWRB and by the enlargement of the embankment (Page B-7). Additional modifications, also designed by the NHWRB, occurred in 1962 when the original spillway was converted into two sluiceways with stoplogs and a new concrete ogee spillway was added. These alterations resulted in the dam's present configuration.

(i) Normal Operational Procedure

A NHWRB dam tender visits the dam at least weekly and reports water levels referenced to the brass plug back to the Concord office. The Board's engineers, in turn, direct any operations necessitated by the operator's input. In late summer or early fall, the pond is drawn down approximately one foot in anticipation of fall storms and spring runoff.

1.3 Pertinent Data

(a) Drainage

The drainage area for Powwow Pond contains 30.6 square miles of forested terrain varying from relatively flat near the pond itself to steeply sloping in some portions farther west. The basin contains considerable permanent development dispersed throughout the area.

(b) Discharge at Damsite

(1) Outlet Works

The dam's outlet works consist of the three bay sluiceway on the left side. Two of the bays are 5 feet wide while the third is 5.5 feet wide. The two leftmost bays have inverts at El. 111.8, while the right bay has its invert at El. 106.2. The sluiceways are intended to hold stoplogs up to the permanent crest elevation at El. 113.7.

(2) Maximum Known Flood at Dam Site

The maximum water level at the dam since the 1962 reconstruction occurred in 1973 when water flowed approximately 2.2 feet deep over the spillway according to NHWRB records.

(3) Spillway capacity at maximum pool elevation: 975 cfs at El. 118.2

(4) Gate capacity at normal pool elevation: 450 cfs at El. 113.7

(5) Gate capacity at maximum pool elevation: 1280 cfs at El. 118.2

(6) Total discharge capacity at maximum pool elevation: 2255 cfs at El. 118.2

(c) Elevation (feet above MSL)

(1) Top of dam: 118.2

(2) Maximum pool: 118.2

(3) Recreational pool: 113.7

(4) Spillway crest: 113.7

(5) Streambed at centerline of dam: 106.2

(6) Maximum tailwater: Unknown

(d) Reservoir

(1) Length of recreational pool: 1.1 miles

(2) Length of maximum pool: Unknown

(e) Storage (acre-feet)

(1) Recreational pool: 400

(2) Top of Dam: 1700

(f) Reservoir Surface (acres)

(1) Top dam: Unknown

(2) Recreational pool: 288

(g) Dam

(1) Type: Earthfill

(2) Length: 250 feet ±

(3) Height: 12 feet (structural and hydraulic)

(4) Top width: 15 feet ±

(5) Side slopes: 2:1

(6) Zoning, impervious core and grout curtain: Unknown

(7) Cutoff: Plans indicate 1 foot thick concrete walls carried to impervious material at back of spillway and at toe of downstream apron and concrete core walls extending from endwalls approximately 8 feet into embankments and within 1 foot of top of dam

(f) Spillway

(1) Type: Concrete gravity

(2) Length of weir: 34 feet

(3) Crest elevation: 113.7 feet

(4) Gates: None

(5) U/S channel: Broad, deep approach from pond

(6) D/S channel: Wide with rock bottom and overhanging vegetation

(g) Regulating Outlets

The size and inverts of the three bay sluiceway are given in subparagraph 1.3(b) (1). Stoplogs are manually installed and removed.

## SECTION 2 - ENGINEERING DATA

### 2.1 Engineering Records

The design of this dam is quite simple and incorporates no unusual features. No original design drawings or calculations are available. Significantly lacking are data concerning foundation conditions and embankment construction.

### 2.2 Construction Records

Plans for the dam reconstructions in 1940 and 1962 are included in Appendix B. These drawings are, in general, quite detailed and contain only minor deviations from the as-built configuration.

### 2.3 Operation Records

The NHWRB operates the dam in a manner consistent with its intended purpose and engineering features.

### 2.4 Evaluation of Data

(a) Availability

The absence of design drawings and calculations and of foundation and embankment data are significant shortcomings, but are somewhat mitigated by the availability of the construction plans. An overall marginal assessment for availability is, therefore, warranted.

(b) Adequacy

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is thus based primarily on the visual inspection, past performance and sound engineering judgement.

(c) Validity

Since the observations of the inspection team generally confirm the information contained in the construction drawings, a satisfactory evaluation for validity is warranted.

## SECTION 3 - VISUAL OBSERVATIONS

### 3.1 Findings

(a) General

The Trickling Falls Dam is in FAIR condition at the present time. Considerable routine maintenance is required to correct minor deficiencies on all parts of the structure.

(b) Dam

(1) Embankments (Photo 1)

The dam's embankment is divided into two sections, each approximately 100 feet long, by the spillway and the three bay sluiceway. Both sections have a maximum height of approximately 12 feet. Pages B-6 and B-7 contain the only information available concerning the internal construction of the embankments. As the plans indicate, the present embankment was constructed by placing granular fill over an existing earthfill structure. Additionally, the plans show concrete core walls extending from the endwalls 8 feet into the embankments.

Inspection of the embankments revealed no evidence of horizontal or vertical movement. Some minor erosion is evident at the junction of the right endwall with the embankment, as riprap has been placed on the upstream face and as the embankment is approximately 8 inches lower than the endwall at this location. The slopes are covered with thick, low brush and many trees which hinder a thorough inspection of the embankment. There is no evidence of any sloughing or cracking of the fill. No deficiencies were noted at the abutments, where the embankments tie into naturally higher ground. Neither the plans nor the inspection reveal evidence of any drainage features for the embankment.

Two seepage areas were noted during the inspection. At the junction of the left endwall and its downstream $90^{\circ}$ return wall, seepage on the order of 2 gpm was observed through a void in the concrete. Approximately 20 feet to the left of this point, a second small seepage of approximately 0.1 gpm was detected at the toe of the embankment. The water was clear with no evidence of soil particle movement.

(2) Spillway

The surface of the spillway exhibits minor surface erosion which is not detrimental to the structure. A vertical construction joint located at approximately mid-length of this structure and a horizontal construction joint located over the full length of the structure approximately 6 feet below the crest are slightly open. These openings are, however, not detrimental to the safety of the structure.

(3) Buttress

The buttress which separates the spillway from the sluiceways has been subjected to erosion, spalling, random cracking and efflourescence and has an open horizontal joint. A minor spall with associated efflourescence is located at a vertical construction joint 3 feet upstream of the spillway crest on the right side of the buttress. The balance of this face of the buttress exhibits no signs of cracks or efflourescence. The left side of the buttress exhibits considerable random cracking both upstream and downstream of the adjacent sluiceway. A vertical joint approximately 5 feet downstream of the sluiceway has been repaired with epoxy mortar. The upstream end of this buttress is eroded to an elevation approximately 5 inches below the spillway crest. This erosion is approximately 6 inches high and 2 inches deep and extends around the end of the wall. Surface erosion is evident downstream of the sluiceways up to 4 feet above the concrete sill. The erosion, spalling, cracking and efflourescence may be attributed to alternate freeze and thaw cycles combined with moisture penetration into the concrete surfaces.

(4) Sluiceway Piers (Photo 2)

The downstream end of the base of the right pier is eroded and spalled and its sidewalls suffer from minor surface erosion, random cracking and efflourescence. The surface erosion is evident up to 4 feet above the sill. The upstream nose of this pier is eroded from the spillway crest to a point 12 inches lower.

The surface erosion may be attributed to cavitation and the random cracking and efflourescence to alternate freeze and thaw cycles combined with moisture penetration into the concrete surfaces.

The left pier displays minor surface erosion on its sidewalls and a crack at its connection with the concrete service walkway. Surface erosion of its upstream nose is similar to the right pier. The surface erosion may be attributed to cavitation and the crack to shrinkage forces.

The concrete sill below the sluiceway outlets exhibits minor surface erosion.

(5) Right Endwall

Inspection of the right endwall revealed a vertical crack upstream of the spillway which has been pointed with epoxy mortar. Minor hairline cracks with traces of efflourescence are evident downstream of the spillway.

(6) Left Endwall (Photo 3)

The inspection of this endwall was divided into two phases which consisted of conditions upstream and downstream of the sluiceway stoplogs.

The portion of this endwall upstream of the stoplogs exhibits random cracking with minor efflourescence. Patching repairs with epoxy mortar have been carried out immediately upstream of the stoplog guides. The repairs are in good condition.

The $90^{\circ}$ return of the endwall upstream of the sluiceways is in good condition. It was noted that a horizontal and a vertical construction joint are well sealed. There is no evidence of cracks, spalls or efflourescence.

The portion of this endwall downstream of the stoplogs was refaced with a mortar-stucco finish. The original wall finish is not visible. However, the surface finish of this wall exhibits random cracking over 75% of its face.

In addition to the foregoing, a horizontal (longitudinal) crack, located approximately 4 feet above the sluiceway outlet sill, exists over the entire length of this wall. Spalls and diagonal and random surface cracks with a high degree of efflourescence are prevalent over the last 10 feet of the endwall. A void is located in the plane of the longitudinal crack and is approximately 6 inches long, 4 inches high and 6 inches deep. It is apparent that the horizontal crack is the location of a "stuccoed over" construction joint. Seepage through the endwall has caused erosion, spalling, cracking and the high concentration of efflourescence.

The $90^{o}$ return of the endwall downstream of the stoplogs has sheared and translated away from endwall by approximately 1.5 inches. Inspection of the opening revealed that this return wall is not structurally tied to the endwall and that the wall is 12 inches thick without any back batter. The base of this wall and the end of the abutment are eroded, with seepage flowing out of the void. The erosion covers a surface area of approximately 12 inches by 18 inches and is 12 inches deep at its greatest penetration. The seepage was in the range of 2 gpm. The displacement of this wall may be attributed to active earth pressures, and to frost action to a lesser extent.

(c) Appurtenant Structures

(1) Concrete Walkway

The concrete walkway is in good condition.

(2) Safety Railing

Two top horizontal rails approximately 15 feet in overall length are missing above the sluiceway openings. The balance of the rails are in good condition.

(d) Reservoir

An examination of the reservoir shoreline revealed no evidence of movement or other instability. No significant sedimentation exists behind the spillway. Observation of the surrounding area showed no evidence of work in progress or recently completed which might increase the flow of sediment into the pond.

Additionally, there were no changes to the surrounding watershed which might adversely affect the runoff characteristics of the basin. There is considerable permanent development along the south shore of the pond.

(e) Downstream Channel (Photo 4)

There are no downstream conditions which adversely affect the operation of the dam or which pose a hazard to the safety of the structure. While the road bridge just downstream of the dam does create a hydraulic constriction, its existence has no detrimental effect on the structure, especially in light of the dam's limited operational capacity. Some maintenance of the downstream channel is necessary, as it contains considerable debris and overhanging trees which could become obstructions to flow during a flood. While the two downstream rubble training walls are in generally poor condition, they pose no significant problems for operation of the dam.

## 3.2 Evaluation

As mentioned previously, the Trickling Falls Dam is in FAIR condition. Because most of the dam's major components are readily accessible for examination, the visual inspection provided a satisfactory basis for assigning a condition rating.

## SECTION 4 - OPERATIONAL PROCEDURES

### 4.1 Procedures

As mentioned previously, a dam tender from the NHWRB visits the dam at least weekly and reports water levels back to the Board's offices. The Board's engineers, in turn, direct any operations deemed necessary. The pond is drawn down approximately one foot in late summer or early fall in anticipation of fall storms and spring runoff.

### 4.2 Maintenance of Dam

The dam tender also inspects the condition of the dam during his visits and periodically files a written report with the Board. The engineers then initiate whatever actions are deemed necessary to effect repairs. Additionally, a staff engineer inspects the dam at least annually.

### 4.3 Maintenance of Operating Facilities

The procedures outlined in subparagraph 4.2 apply to sluiceways and stoplogs also.

### 4.4 Description of Any Warning System in Effect

*No formal warning system exists for this dam.*

### 4.5 Evaluation

While the dam is in overall fair condition, the large number of minor deficiencies indicate that increased attention to routine maintenance is warranted. Due to the absence of any real downstream hazard, the lack of a formal warning system is not a significant problem at this time.

## SECTION 5 - HYDROLOGIC/HYDRAULIC

### 5.1 Evaluation of Features

(a) Available Data

The primary data source for Trickling Falls Dam is the records of the NHWRB. These files contain construction plans showing the sizes of the original dam and the subsequent major alterations in 1940 and 1962. Additionally, several pages of hydraulic and hydrologic calculations for both structures are also available. These data are supplemented by two 1941 reports by the New Hampshire Water Control Commission entitled "Data on Reservoirs and Ponds in New Hampshire" and "Data on Dams in New Hampshire."

(b) Experience Data

According to the records of the NHWRB, the highest water level recorded at Trickling Falls Dam since its reconstruction in 1962 is approximately 2 feet above the brass pin during a storm in 1973. This level equates to a water surface elevation of approximately 116.0 feet MSL which probably produced a discharge over the dam on the order of 500 cfs.

(c) Visual Observations

Trickling Falls Dam is an earthfill structure with a concrete gravity spillway and outlet works. The dam has an overall crest length of about 250 feet. The top width of the dam is variable with a minimum width of about 15 feet.

The dam contains a 34 foot long concrete ogee spillway and a three bay sluiceway with stoplogs having a total effective width of 15.5 feet. Two of the bays are 5.0 feet in width while the third is 5.5 feet wide. The spillway crest height is about 7.5 feet above the streambed and 4.5 feet lower than the top of the dam. Pond levels may be controlled to some extent by varying the height of the stoplogs. Two of the sluiceway bays have permanent concrete bases two feet lower (El. 111.7) than the spillway crest. The third bay may be opened all the way to the base slab of the structure at an elevation of about 106.2 feet. At the time of the inspection, all stoplogs were set at the same height as the spillway and the pond level was approximately 0.5 feet below the spillway crest. With the exception of a small amount of leakage between the stoplogs, there was no discharge through the dam.

Just downstream of the dam is a constriction created by a road bridge. The highway embankment is at a slightly higher (about 0.5 feet) elevation than the dam spillway and the bridge has a 17.0 foot wide clear span. Beyond this bridge the stream resumes a normal channel and is unobstructed, with little development in the immediate vicinity.

(d) Overtopping Potential

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow a large flood flow to pass. This analysis requires using the storage and discharge characteristics of the structure to evaluate the impact of an appropriately sized Test Flood. The available discharge capacity calculations included in the NHWRB records were not used since they predate the current configuration of the dam.

Guidelines for determining a recommended Test Flood based on the size and hazard potential classification of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers (COE). As specified in these guidelines, the appropriate Test Flood for a dam classified as INTERMEDIATE in size and LOW in hazard potential is between the 100 year flood and one half the Probable Maximum Flood (PMF).

The magnitude of the 100 year peak inflow to Powwow Pond is estimated using a regression relationship provided by the USGS in Water Resources Investigations 78-47, "Progress Report on Hydrologic Investigations of Small Drainage Areas in New Hampshire." This equation, which uses the drainage area, main channel slope and the 24-hour, 2-year frequency precipitation to estimate peak inflow, yields a 100-year inflow of about 4500 cfs for the drainage basin.

The chart of "Maximum Probable Peak Flow Rates" obtained from the COE, New England Division, is used to define the applicable PMF. For the 30.6 square mile drainage area above Trickling Falls Dam, which has a topography between "flat" and "rolling", the chart gives a PMF flow of 900 cfs per square mile. This runoff results in a total PMF of 27,500 cfs, or a one-half PMF flow of 13,750 cfs.

The "Recommended Guidelines" suggest that if a range of values is indicated for the Test Flood, the magnitude most closely related to the involved risk should be selected. Since the risk for Trickling Falls Dam is midway within the LOW hazard category, a Test Flood of 7500 cfs is used as inflow to Powwow Pond.

The attenuation of the peak due to storage is estimated using the procedure suggested by the COE New England Division for "Estimating the Effect of Surcharge Storage on Maximum Probable Discharges." The Storage-Stage Curve used for these calculations is developed assuming that the surcharge storage available in a pond is equal to the surface area of the pond times the depth of surcharge. No spreading or increase in surface area with increasing depth is considered. The use of the recommended procedure shows that, in this case, pond storage does have a significant damping effect on the magnitude of the peak flow since a 16 percent reduction in peak flow to 6300 cfs as the corrected Test Flood flow results.

The Stage-Discharge curve is developed by defining discharge as the sum of flow over the spillway and stoplogs, the flow over the dam crest and the flow over the slopes at the end of the dam. These calculations assume a stoplog height in all three sluiceways up to the level of the main spillway (El. 113.7) and that there would be insufficient opportunity to remove the stoplogs in an emergency. Paragraph 1.3 presents discharge capacities assuming that stoplogs could be removed. Application of the corrected peak Test Flood discharge of 6300 cfs to the derived Stage-Discharge relationship results in a maximum stage at the dam of 7.3 feet above the spillways (El. 121.0), which is 2.8 feet above the crest of the dam.

## 5.2 Hydrologic/Hydraulic Evaluation

The results of the hydrologic and hydraulic calculations indicate that the outlet capacity of Trickling Falls Dam is insufficient to pass the appropriate Test Flood without significant overtopping. This conclusion is based on a likely, but relatively low outlet capacity condition with the stoplogs in place.

Even if all stoplogs could be removed in the event of a severe storm, which might be difficult under the present operating policy, the Test Flood would still result in the dam being overtopped by more than 2 feet. The maximum capacity of this outlet without overtopping the crest of the dam is about 1500 cfs with the stoplogs at the normal pond level and about 2200 cfs with all stoplogs removed.

## 5.3 Downstream Dam Failure Hazard Estimates

The flood hazards in downstream areas resulting from a failure of Trickling Falls Dam are estimated using the procedure suggested in the COE New England Division's "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs." This procedure accounts for the attenuation of dam failure hydrographs in computing flows and flooding depths for downstream reaches.

For these calculations, it is assumed that the dam fails with the pond stage just overtopping the dam crest at El. 118.2. This level corresponds to a height of 12.0 feet above the stream bed. For an assumed breach width of 60 feet, the resultant peak discharge due to dam failure is 4300 cfs.

Downstream of the dam there are essentially three reaches pertinent to these calculations. The first reach is 200 feet in length and includes the region between the dam and the road bridge. The second reach extends from the bridge to a point about 500 feet downstream where the stream widens considerably. The third reach is a large flat swampy area with an estimated floodplain width of 1000 feet.

The attenuation of the dam failure hydrograph through Reach 1 is determined largely by the constricted channel opening through the road bridge. This embankment is a significant one that would be overtopped by the flows released, but because of its paved surface would probably not fail as a result of overtopping. Since the distance between the structures is so small, the pond stage may be applied at the bridge to determine the flood flow passing on to Reach 2 as the sum of the flows through the bridge opening and the flow over the roadway embankment. This calculation indicates that the peak dam failure flow would be reduced from 4,300 cfs to 2,030 cfs in passing through this constriction.

Downstream of the bridge in Reach 2, a flow depth of about 6.4 feet would develop with very little additional attenuation of the flow. One home located just below the bridge, appears to be the only structure that might be endangered. This structure, however, is located above the 6.4 feet of flooding depth computed for this reach.

In Reach 3 the large volume of storage available in the swamp area would further attenuate the flow and produce a flood depth of less than 5 feet. No structures that would be affected by this depth of flow are located in this area.

## SECTION 6 - STRUCTURAL STABILITY

### 6.1 Evaluation of Structural Stability

(a) Visual Observations

The extensive field investigations of the dam revealed no significant displacements and/or distress which warrant the preparation of structural stability calculations based upon assumed sectional properties and engineering factors.

(b) Design and Construction Data

No design stability calculations are available. The construction plans contained in Appendix B, however, are quite detailed and would be of significant value were a stability analysis deemed necessary.

(c) Operating Records

The dam's operating records reveal no evidence of instability under past flow conditions.

(d) Post Construction Changes

The alterations accomplished in 1940 and 1962 significantly improved the dam's stability by greatly increasing discharge capacity and by providing additional mass to resist sliding and overturning forces.

(e) Seismic Stability

This dam is located in Seismic Zone No. 2 and, in accordance with recommended Phase I guidelines, does not warrant seismic analyses.

## SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

### 7.1 Dam Assessment

(a) Condition

The Trickling Falls Dam is in FAIR condition at the present time.

(b) Adequacy of Information

The lack of in-depth engineering data does not permit a definitive review. Therefore, the adequacy of the dam cannot be assessed from the standpoint of reviewing design and construction data. This assessment is thus based primarily on the visual inspection, past performance and sound engineering judgement.

(c) Urgency

The improvements described herein should be implemented by the owner within two years of receipt of the Phase I Inspection Report.

(d) Need for Additional Investigation

No additional investigations are deemed necessary at this time.

### 7.2 Recommendations

As discussed in Section 5, the discharge capacity of the dam is insufficient to pass the Test Flood selected without significant overtopping of the dam. It is therefore recommended that further hydrologic studies of the spillway adequacy be made.

### 7.3 Remedial Measures

The Trickling Falls Dam requires the following operating and maintenance improvements:

(1) Repair the erosion at the junction of the right endwall and the right embankment and provide suitable riprap protection to preclude similar problems in the future.

(2) Clear both embankments of all brush and trees and institute a regular program of slope maintenance.

(3) Closely monitor the two seepage areas, paying particular attention to changes in quantity and turbidity. If necessary, institute remedial measures to preclude damage from the seepages.

(4) Repair all deteriorated concrete surfaces and joints.

(5) Stabilize and repair the $90^{o}$ return wall at the downstream end of the left endwall.

(6) Repair the safety railing over the three bay sluiceway.

(7) Trim or remove all trees and vegetation along the approach channel and the downstream channel which might become obstructions to flow in the event of a serious storm. Institute a regular program of removing debris from in and around the channel areas.

(8) Monitor the condition of the downstream training walls to preclude their becoming obstructions to flow. Repair or remove the walls if necessary.

(9) Train local municipal officials in the proper operation of the dam and provide them with the necessary operating tools. Such a program could decrease response time in pulling stoplogs in the event of an emergency.

(10) Institute a formal warning system during periods of flooding.

(11) Perform a technical inspection of the dam every two years.

## 7.4 Alternatives

There are no meaningful alternatives to the accomplishment of the above listed actions.

# APPENDIX A

## VISUAL INSPECTION CHECKLIST

## INSPECTION TEAM ORGANIZATION

Date: September 21, 1978

NH 00440
TRICKLING FALLS DAM
East Kingston, New Hampshire
Powwow River
NHWRB 72.01

Weather: Sunny and warm

### INSPECTION TEAM

| | | |
|---|---|---|
| Robert Minutoli | Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) | Team Captain |
| William Zoino | GZD | Soils |
| Nicholas Campagna | GZD | Soils |
| Andrew Christo | Andrew Christo Engineers (ACE) | Structural |
| Paul Razgha | ACE | Structural |
| Richard Laramie | Resource Analysis, Inc. | Hydrology |

Mr. Pattu Kesavan of the NHWRB accompanied the inspection team.

| CHECK LISTS FOR VISUAL INSPECTION | | |
|---|---|---|
| AREA EVALUATED | BY | CONDITION & REMARKS |
| EMBANKMENT | | |
| Vertical alignment and movement | | No deficiencies noted |
| Horizontal alignment and movement | | No deficiencies noted; top width 15' ± |
| Condition at abutments | | No deficiencies noted; rubble wall D/S of left abutment |
| Trespassing on slopes | | No evidence |
| Sloughing or erosion of slopes or abutments | | Some erosion on upstream side at junction with right endwall; embankment 8" lower than wall; some riprap has been placed |
| Rock slope protection | | Small amount on upstream side at junction with right endwall |
| Unusual movement or cracking at or near toe | | None noted |
| Unusual downstream seepage | | Small seepage (≤ 0.1 gpm) at D/S toe of left embankment approximately 20 feet from left endwall; small seepage (≤ 2 gpm) under intersection of left endwall and D/S 90° return wall; area near base of rubble wall D/S of left abutment is damp, but no identifiable seepage points were noted |
| Piping or boils | | None noted |

CHECK LISTS FOR VISUAL INSPECTION

| AREA EVALUATED | BY | CONDITION & REMARKS |
|---|---|---|
| Foundation drainage features | RC | Plans indicate coarse grained gravel drain under D/S end of spillway |
| Maintenance of slopes | RC | Some trees and considerable heavy brush cover most of slopes and make inspection difficult |
| OUTLET WORKS | | |
| a. Approach Channel | NAC | Broad approach from pond; shoreline along approach is flat; slides unlikely |
| Bottom conditions | | Not visible; bottom covered with leaves |
| Rock slides or falls | | No rock in vicinity |
| Log boom | | None, but steel cable can be installed across spillway |
| Control of debris | | Small amount of debris submerged behind dam |
| Trees overhanging channel | NAC | Many trees along shoreline immediately U/S of dam |
| b. Spillway | | |
| Condition of concrete | | |
| General condition | | Good |
| Erosion or cavitation | | Minor surface erosion on spillway and on left buttress between spillway and sluiceways |
| Spalling | | Minor spalling on left buttress |

| CHECK LISTS FOR VISUAL INSPECTION | | |
|---|---|---|
| AREA EVALUATED | BY | CONDITION & REMARKS |
| Cracking | | Some random cracking on left buttress |
| Condition of joints | | Minor opening of one full length and one full height construction joint on spillway; open horizontal joint on left buttress. |
| Rusting or staining | | None noted |
| Visible reinforcing | | None noted |
| Seepage or efflourescence | | Minor efflourescence on right buttress |
| c. Three Bay Sluiceway | | |
| Condition of concrete | | |
| General condition | | Good |
| Erosion or cavitation | | Severe erosion near bottom of right intermediate pier; minor erosion over remainder of right intermediate and over left intermediate pier |
| Spalling | | Some spalling near bottom of right intermediate pier |
| Cracking | | Random cracking over both intermediate piers |
| Condition of joints | | Considerable erosion of construction joint between right intermediate pier and base slab |
| Rusting or staining | | None noted |
| Visible reinforcing | | None noted |

| CHECK LISTS FOR VISUAL INSPECTION | | |
|---|---|---|
| AREA EVALUATED | BY | CONDITION & REMARKS |
| Seepage or efflourescence | | Some efflourescence on both intermediate piers |
| Condition of stoplogs | | Good; minor leakage between logs |
| Adequately secured (tamperproof) | | Locked in place |
| d. Endwalls | | |
| Condition of concrete | | |
| General condition | | Good except 90° return wall on D/S end of left endwall, which has sheared and translated away from endwall; base of wall adjacent to abutment has eroded approximately 12" deep over a 12" x 18" area; seepage of 2 gpm through void |
| Erosion or cavitation | | None noted |
| Spalling | | Some spalling noted over 10 feet of left wall on D/S end |
| Cracking | | Vertical pointed crack and minor hairline cracks on right wall; on left wall, some random cracking on U/S end; on D/S end of left wall, full length horizontal cracks at one location and random surface cracks over 75% of face |
| Condition of joints | | No deficiencies noted |
| Rusting or staining | | None noted |
| Visible reinforcing | | None noted |

CHECK LISTS FOR VISUAL INSPECTION

| AREA EVALUATED | BY | CONDITION & REMARKS |
|---|---|---|
| Seepage or efflourescence | | Traces of efflourescence near cracks on right wall; some on U/S side of left wall; high degree of efflourescence on last 10 feet of left wall on D/S side |
| e. Walkway | | |
| Condition | | Good |
| Safety railing | | 15 feet of top rails missing, probably removed to facilitate access to stoplogs; remaining railing in good condition |
| OUTLET CHANNEL (immediate area) | | |
| Slope conditions | nac | Downstream channel is broad with heavy vegetation on both sides; old rubble training walls in disrepair |
| Rockslides or falls | | No rock in vicinity |
| Control of debris | | Some debris, including several large tree trunks, in channel |
| Trees overhanging channel | | Heavy overgrowth on both sides which does extend over channel; some vegetation growing in channel |
| Other obstructions | | Concrete highway bridge some 200 feet downstream creates a hydraulic constriction |
| Existence of gages | nac | None; water levels measured from brass plug on U/S face at El. 114 ± (MSL) |

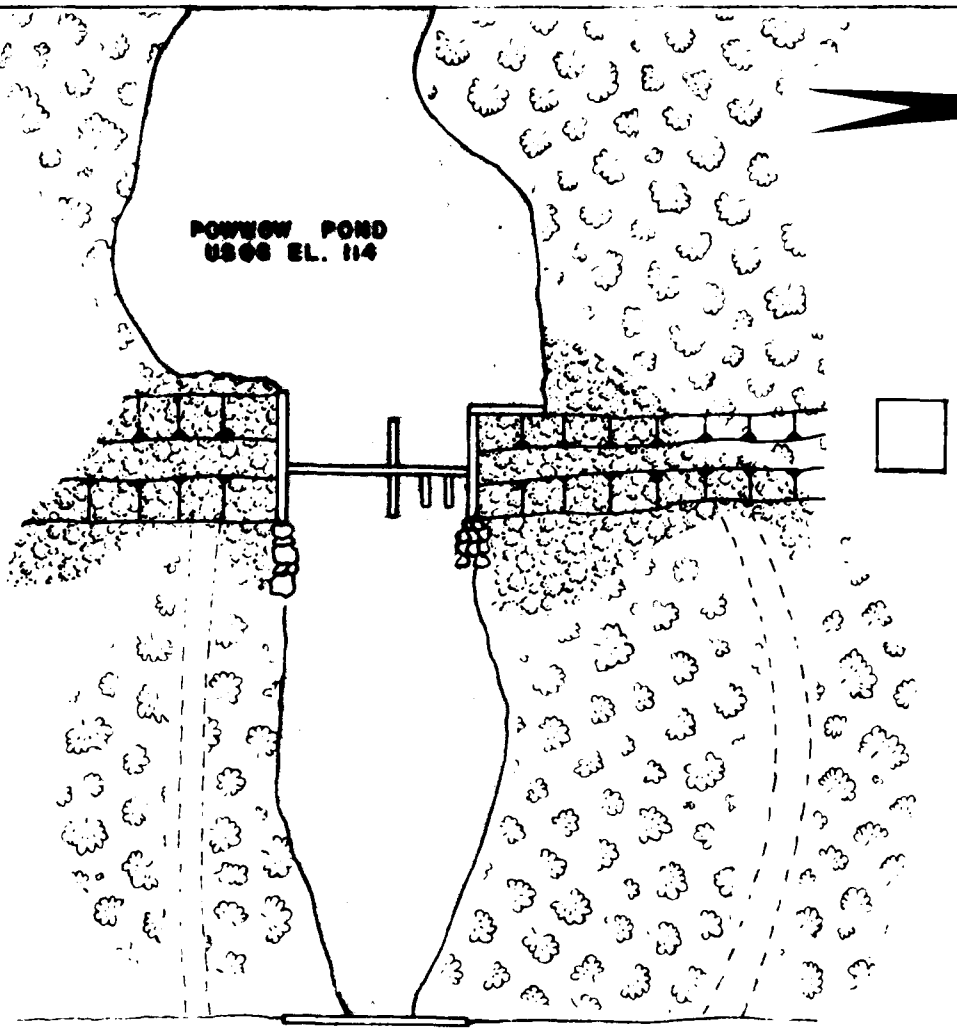
| CHECK LISTS FOR VISUAL INSPECTION | | |
|---|---|---|
| AREA EVALUATED | BY | CONDITION & REMARKS |
| RESERVOIR | | |
| a. Shoreline | | |
| Evidence of slides | | None noted |
| Potential for slides | | Shoreline stable |
| b. Sedimentation | | None noted |
| c. Upstream hazard areas in the event of back-flooding | | Considerable permanent development along south shore of pond |
| d. Changes in nature of watershed (agriculture, logging, construction, etc.) | | None noted |
| DOWNSTREAM CHANNEL | | |
| Restraints on dam operation | | None, given dam's limited operational capacity |
| Potential flooded area | | Only one home within flood plain for a considerable distance D/S |
| OPERATION & MAINTENANCE FEATURES | | |
| a. Reservoir regulation plan | | |
| Normal procedure | MCC | Maintain water at spillway level during summer recreational period; draw down 1 foot in late summer or early fall for flood control |

CHECK LISTS FOR VISUAL INSPECTION

| AREA EVALUATED | BY | CONDITION & REMARKS |
|---|---|---|
| Emergency procedures | nae | Permanent dam tenders could pull stoplogs if necessary, but could be slow due to number of dams covered by NHWRB; no warning system in affect |
| Compliance with designated plan | | Generally satisfactory, but many complaints on file about both low and high pond levels |
| b. Maintenance | | |
| Quality | | Many O & M type repairs are needed at dam |
| Adequacy | poc | Dam inspected weekly by operators and annually by NHWRB engineers |

## APPENDIX B


| | | Page |
|---|---|---|
| FIGURE 1 | Site Plan | B-2 |
| | Plans of 1961 Trickling Falls Reconstruction | B-3 |
| | Plans of 1940 Trickling Falls Reconstruction | B-6 |
| | List of pertinent records not included and their location | B-8 |
| | News release by the NHWRB dated January 18, 1978 concerning Powwow Pond levels | B-9 |




GOLDBERG, ZOINO, DUNNICLIFF & ASSOC, INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

FIG. 1

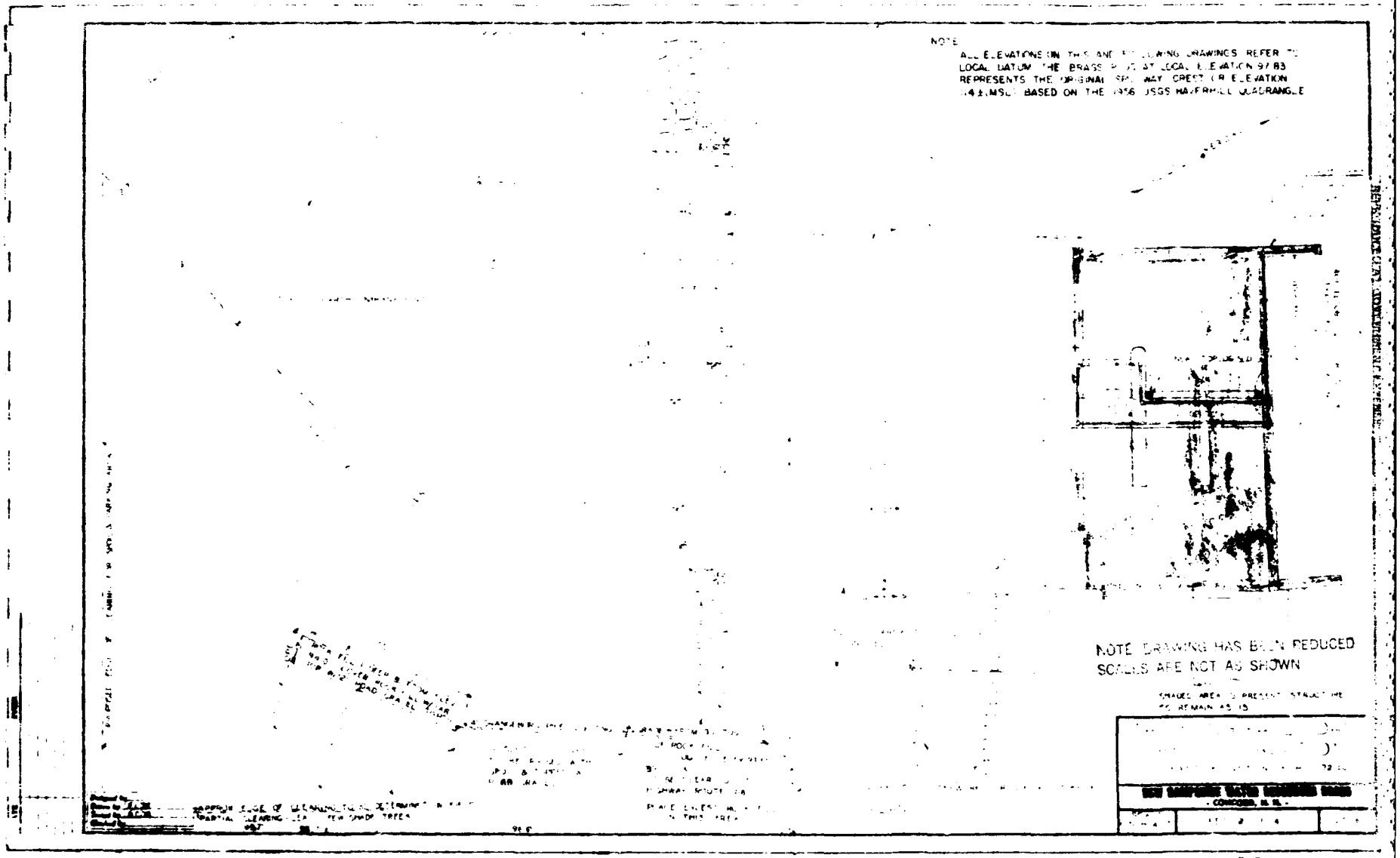
# SITE PLAN

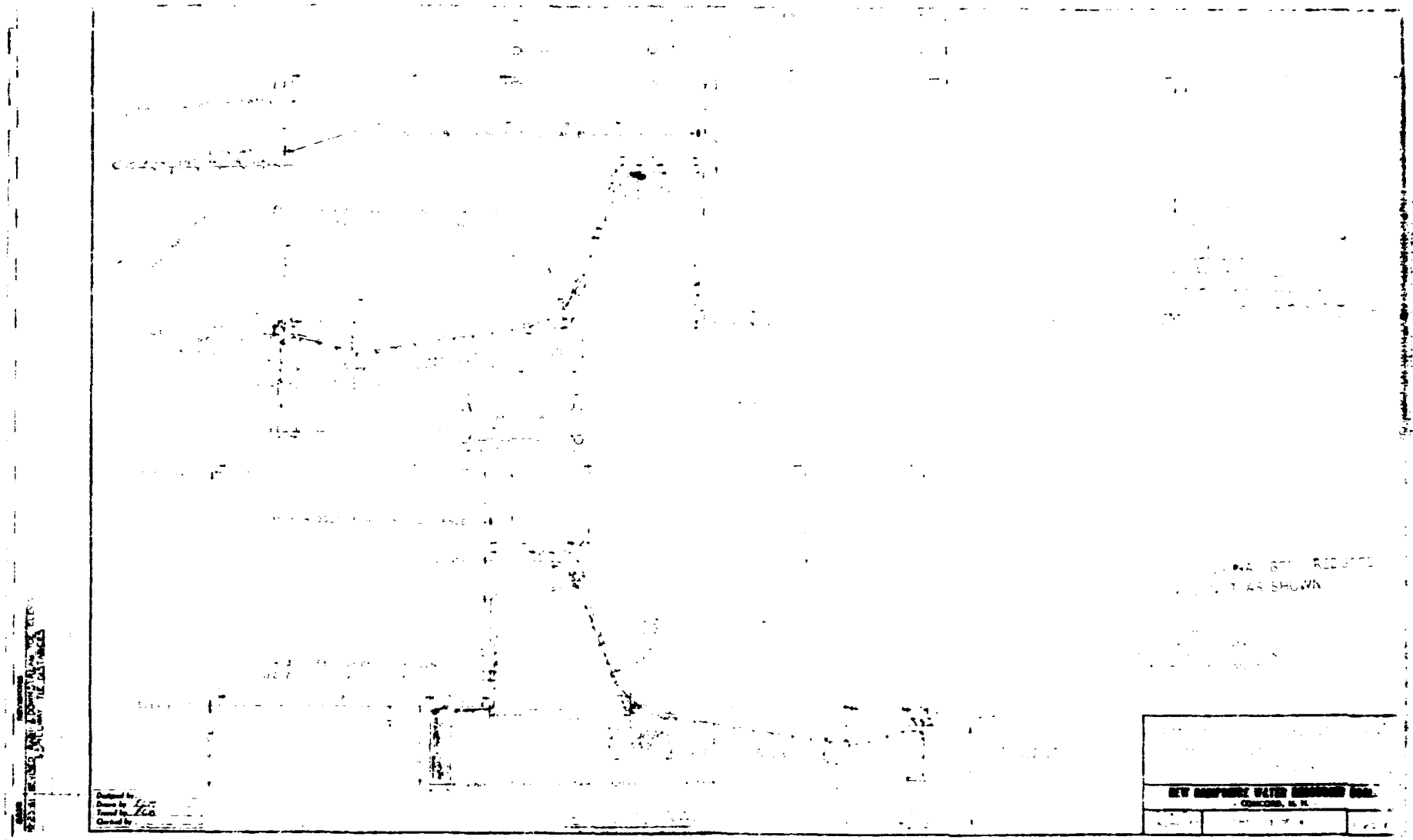
FILE No. 2067

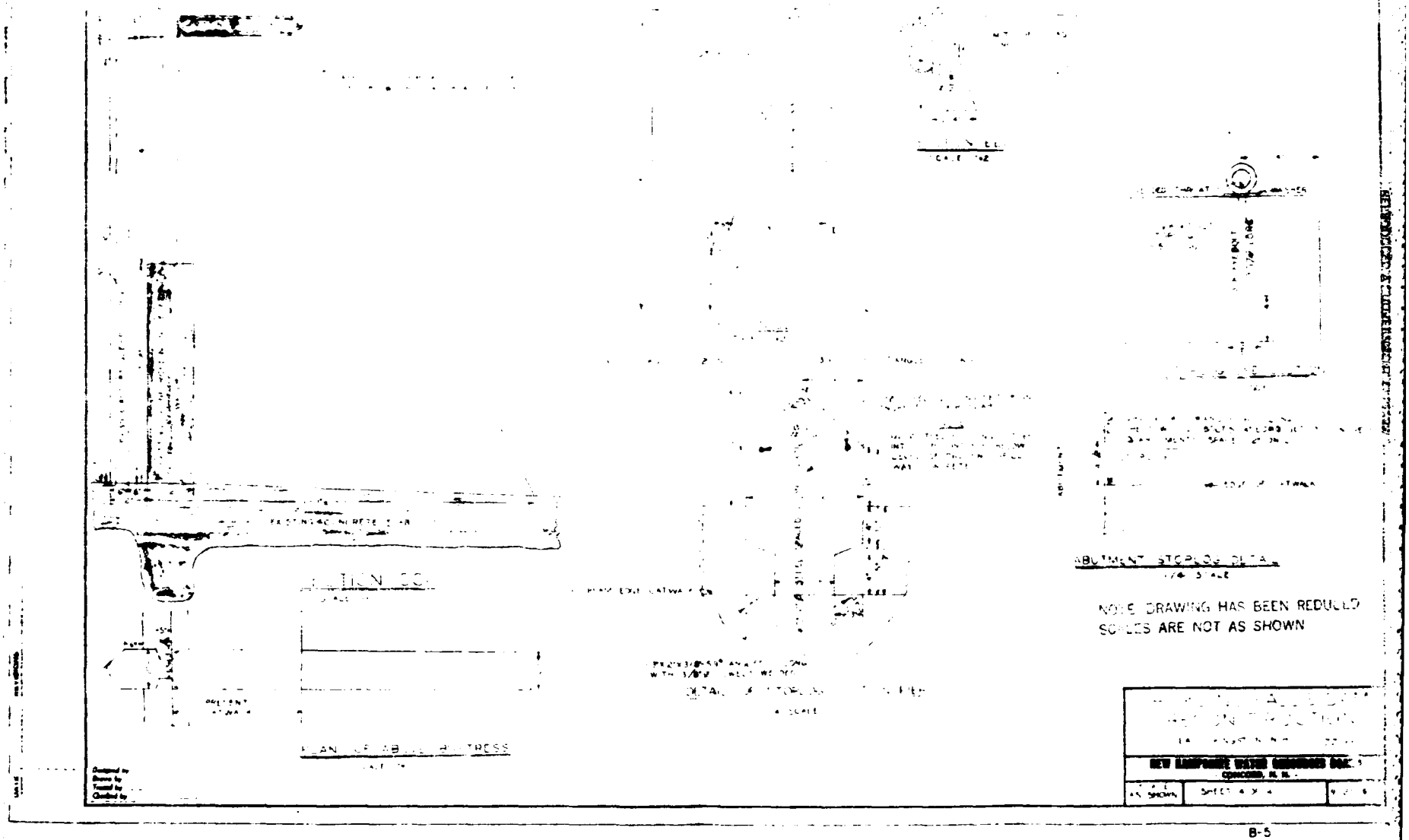
TRICKLING FALLS DAM — NEW HAMPSHIRE

SCALE 1" = 50'

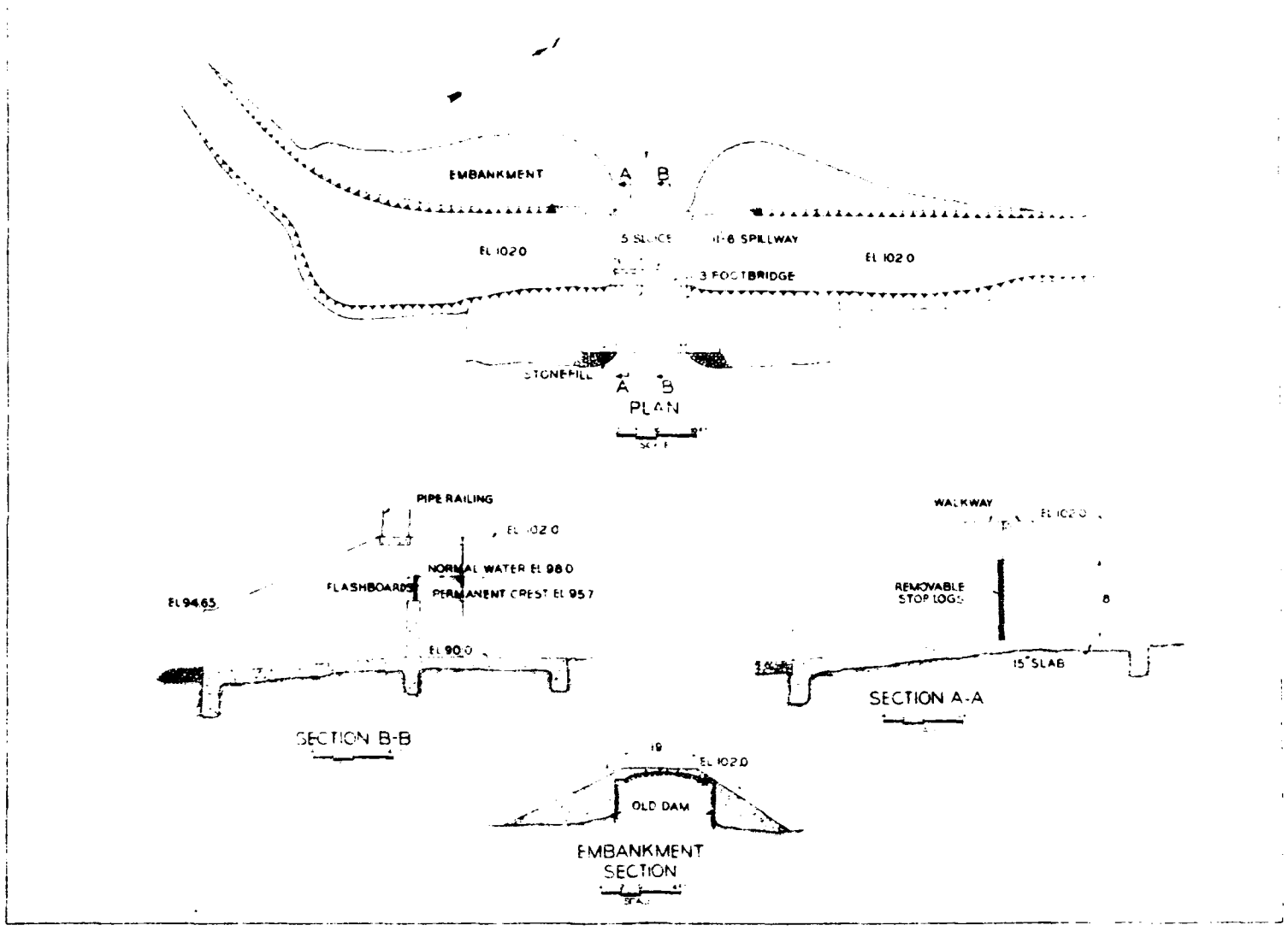
DATE SEPT 1978


NOTE
ALL ELEVATIONS IN THIS AND FOLLOWING DRAWINGS REFER TO
LOCAL DATUM THE BRASS PLUG AT LOCAL ELEVATION 97.83
REPRESENTS THE ORIGINAL SPILLWAY CREST OR ELEVATION
314± MSL BASED ON THE 1956 USGS HAVERHILL QUADRANGLE
NOTE DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN

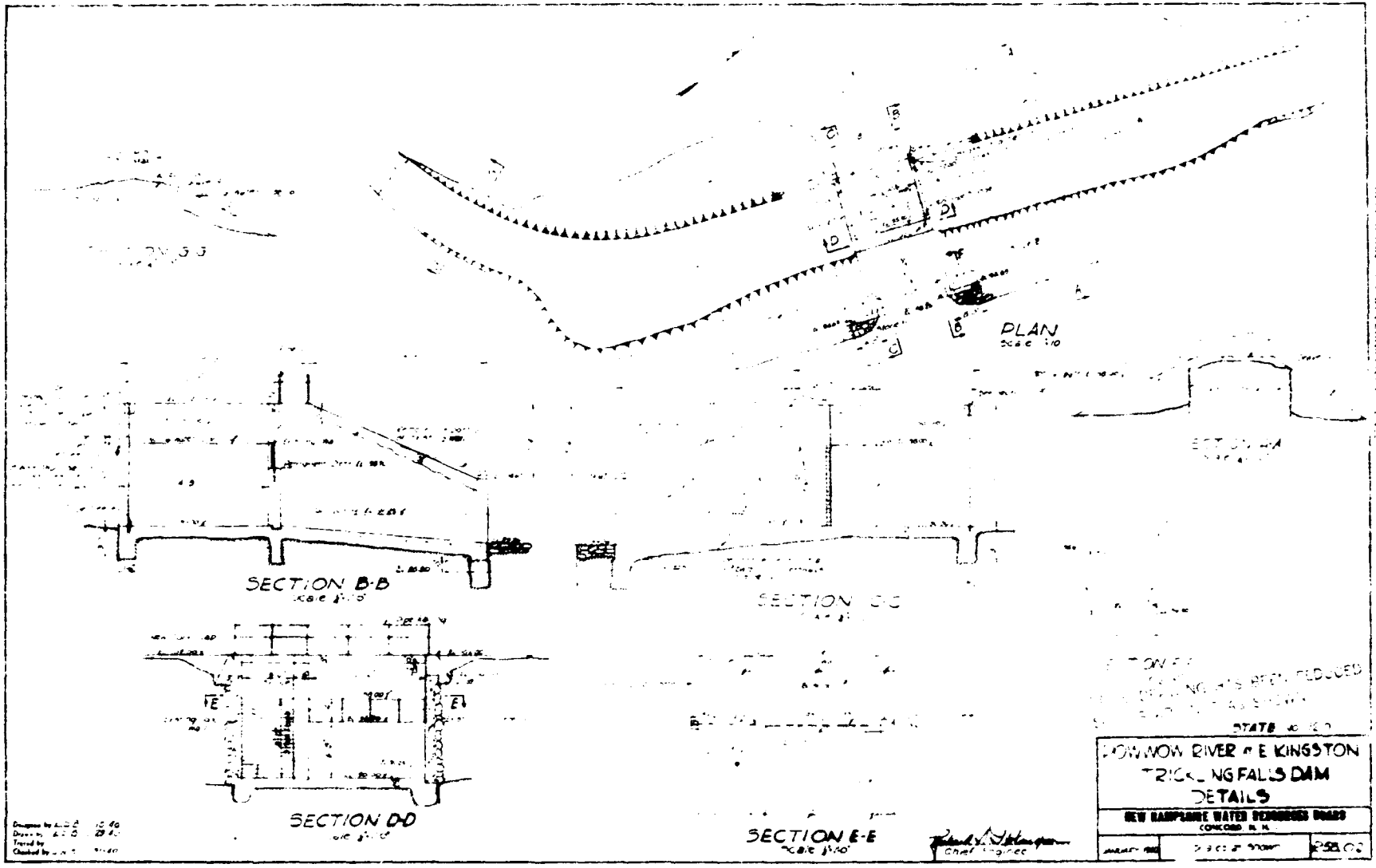




NOTE DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN


EMBANKMENT
A
B
EL 1020
5 SLUICE
11-8 SPILLWAY
EL 102.0
3 FOOTBRIDGE
STONEFILL
A
B
PLAN
PIPE RAILING
EL 102.0
NORMAL WATER EL 98.0
FLASHBOARDS
PERMANENT CREST EL 95.7
EL 94.65
EL 90.0
SECTION B-B
WALKWAY
EL 102.0
REMOVABLE STOP LOGS
8
15" SLAB
SECTION A-A
19
EL 102.0
OLD DAM
EMBANKMENT SECTION

REPRODUCED AT GOVERNMENT EXPENSE



The New Hampshire Water Resources Board, 37 Pleasant Street, Concord, N.H. 03301 maintains a comprehensive correspondence file on the dam dating back to the 1930's. Included in this file are:

(a) Several pages of hydrologic and hydraulic calculations for both the old and new configurations.

(b) A large volume of correspondence from upstream and downstream residents concerning reservoir levels and discharges.

(c) A 1941 report by the New Hampshire Water Control Commission entitled "Data on Reservoirs and Ponds in New Hampshire."

(d) A 1941 report by the same agency entitled "Data on Dams in New Hampshire."

# State of New Hampshire

WATER RESOURCES BOARD

CONCORD 03301

January 18, 1978

N E W S - R E L E A S E

George M. McGee, Sr., Chairman of the New Hampshire Water Resources Board, announces that at a Board meeting held on January 11, 1978 that it was moved, seconded and unanimously voted, that the level of Pow Wow River Pond be maintained to the level of the emergency spillway during the summer recreation months.

This change is a result of the public hearing which was recently held in East Kingston regarding the level of Pow Wow River Pond. In previous years the "full pond" measurement was set at 5 inches below the "pin" which is set in the concrete abutment. The new summer or "full pond" level will be to the emergency spillway crest or an increase of less than 3 inches in pond elevation. This is as requested by those who were in attendance of the public hearing. It should be noted though, that no change is anticipated in the standard fall and winter draw-down schedule. As a consequence of the requested action, a minor decrease is expected in the storage capacity of the dam, hence an increased susceptibility to minor change will occur.

GMMG:GK:njk

cc: WS & PCC
Dept. of Safety
F & G Department
Manchester Union Leader
Concord Monitor

Senator Ward B. Brown
Box 404
East Hampstead, NH 03826

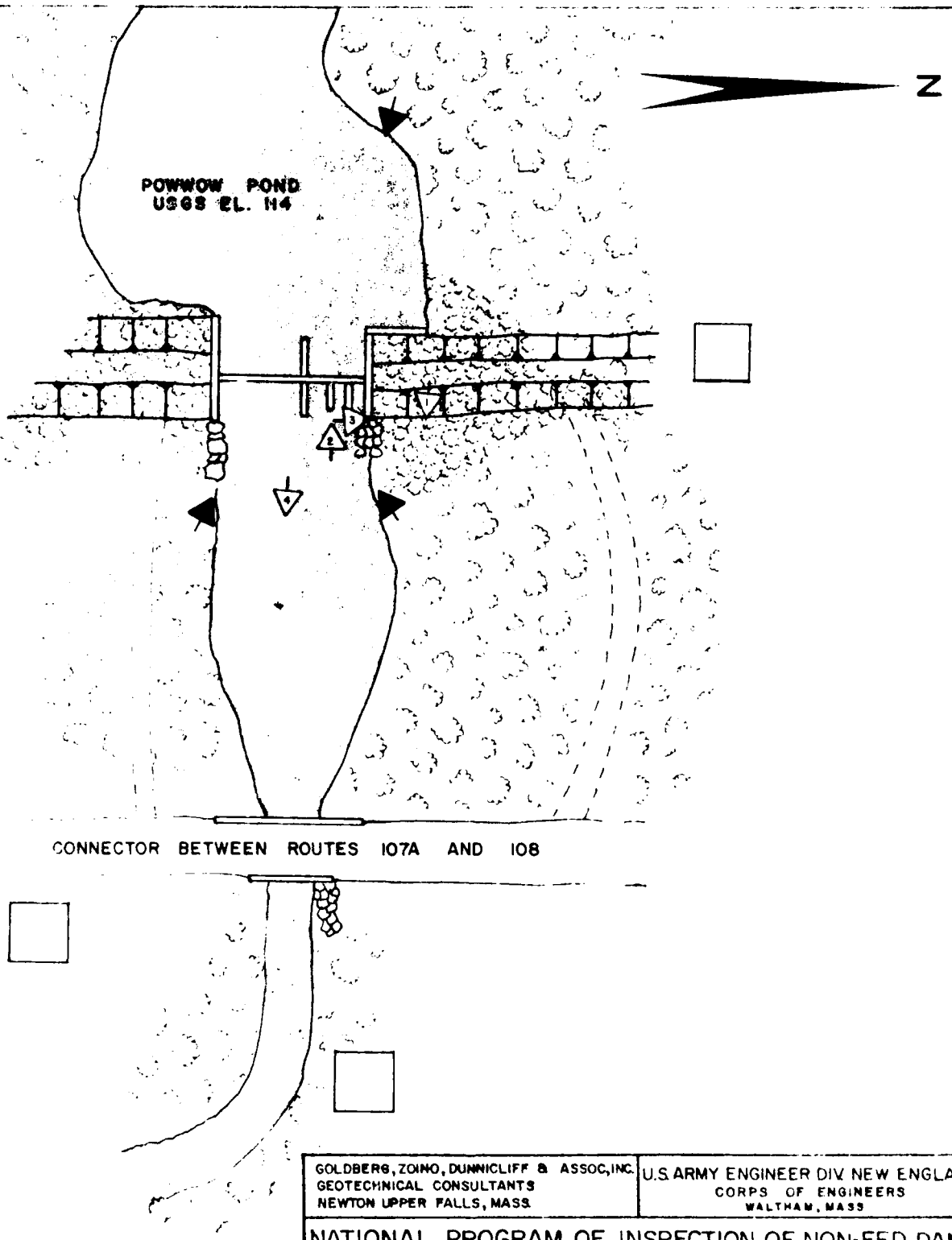
Councilor Dudley W. Dudley
25 Woodman Road
Durham, NH

ok G.M.M Sr.
1/19/78

LIVE FREE OR DIE

# APPENDIX C

SELECTED PHOTOGRAPHS




OVERVIEW PHOTOS

APPENDIX C PHOTOS

| | |
|---|---|
| GOLDBERG, ZOINO, DUNNICLIFF & ASSOC, INC.<br>GEOTECHNICAL CONSULTANTS<br>NEWTON UPPER FALLS, MASS. | U.S. ARMY ENGINEER DIV. NEW ENGLAND<br>CORPS OF ENGINEERS<br>WALTHAM, MASS. |

NATIONAL PROGRAM OF INSPECTION OF NON-FED DAMS

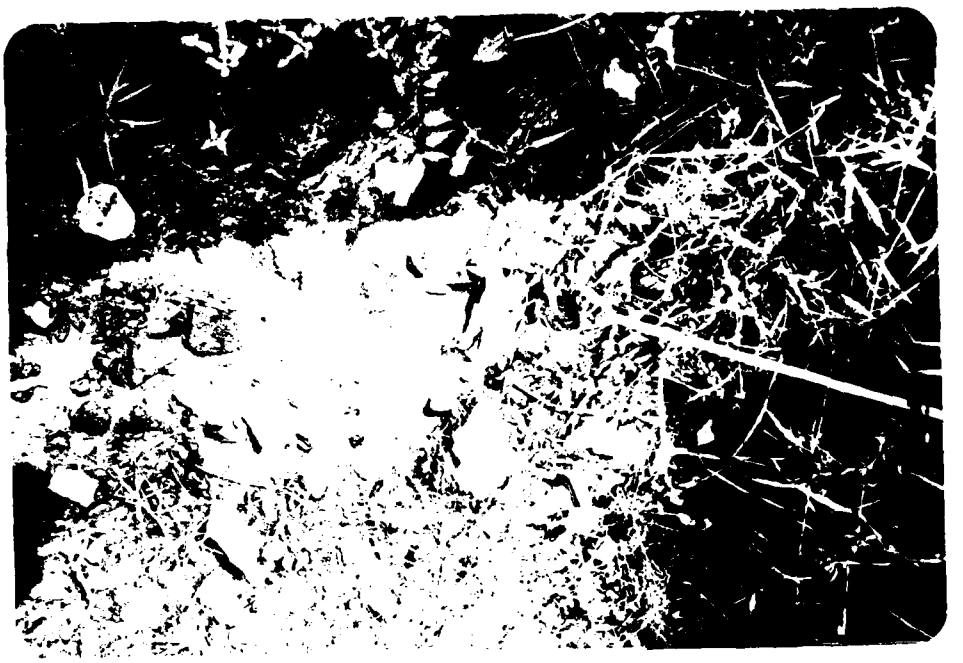
# LOCATION AND ORIENTATION OF PHOTOS

TRICKLING FALLS DAM — NEW HAMPSHIRE

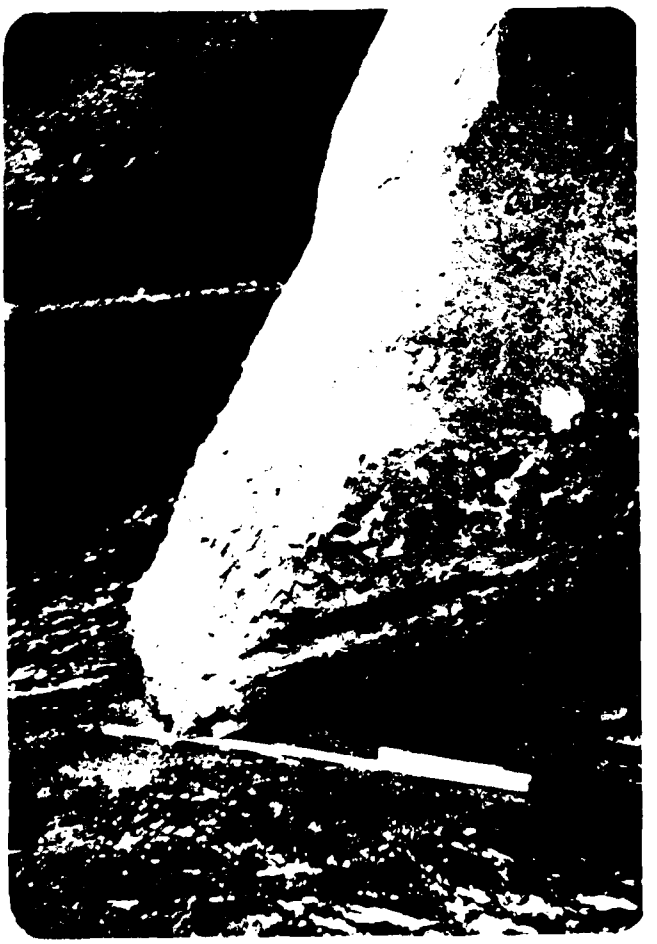
FILE No. 2067

SCALE : 50

DATE SEPT 1978



1. View of seepage at toe of left embankment



2. View of erosion and spalling on left intermediate sluiceway pier

3. View of translation of 90° return wall at downstream end of left endwall and of deteriorated concrete on both walls

4. View from dam of downstream channel and road bridge creating hydraulic constriction

# APPENDIX D

## HYDROLOGIC/HYDRAULIC COMPUTATIONS

Trickling Falls Dam

Size Classification = INTERMEDIATE

Hazard Classification = LOW

∴ Test Flood = 100 yr. freq. flood - ½ PMF

From USGS W.R. Investigations 78-47 the 100-yr peak is:

$$P_{100} = 0.55(A^{1.05} S^{0.56} I^{2.72})$$

where

$P_{100}$ = 100 yr. peak discharge (cfs)
$A$ = drainage area ($mi^2$) = 30.6 $mi^2$
$S$ = main channel slope (ft/mi) = 75 ft/mi
and $I$ = max. 24-hr precip, 2 yr freq (in) = 3.0 in

∴ $P_{100} = 0.55(30.6)^{1.05}(75)^{0.56}(3.0)^{2.72} = 4448$ → use 4500 cfs

The chart of "Maximum Probable Peak Flow Rates" (COE, N.E.) used to define the PMF indicate:

For the 30.6 $mi^2$ drainage area, which has a "flat" to "rolling" topography, the PMF = 900 cfs/$mi^2$

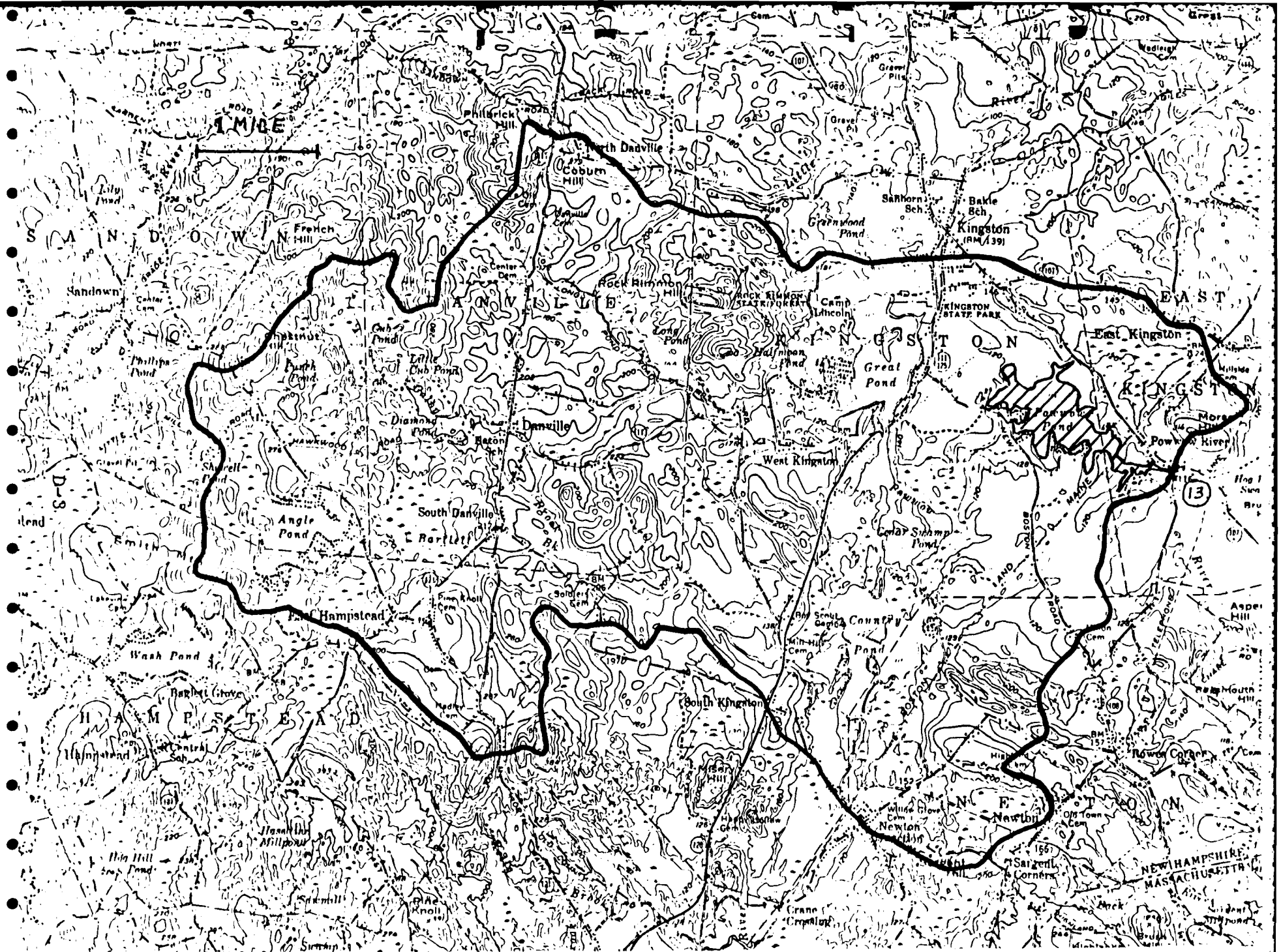
∴ PMF = 900(30.6) = 27,540 → use 27,500 cfs

½ PMF = ½(27,500) = 13,750 cfs

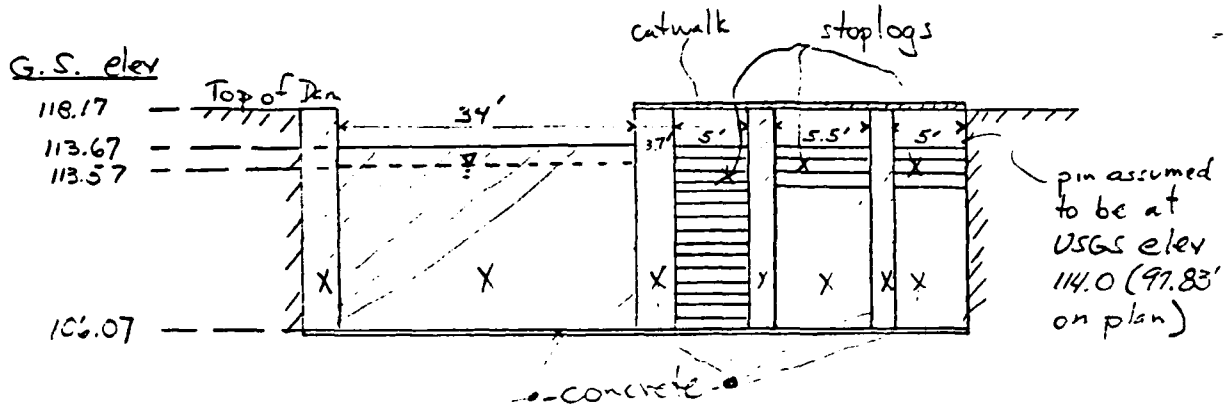
The Test Flood Range is → 4500 to 13,750 cfs

To reflect the risk involved, which places this dam within the moderate LOW category, a Test Flood of 7500 cfs is used.

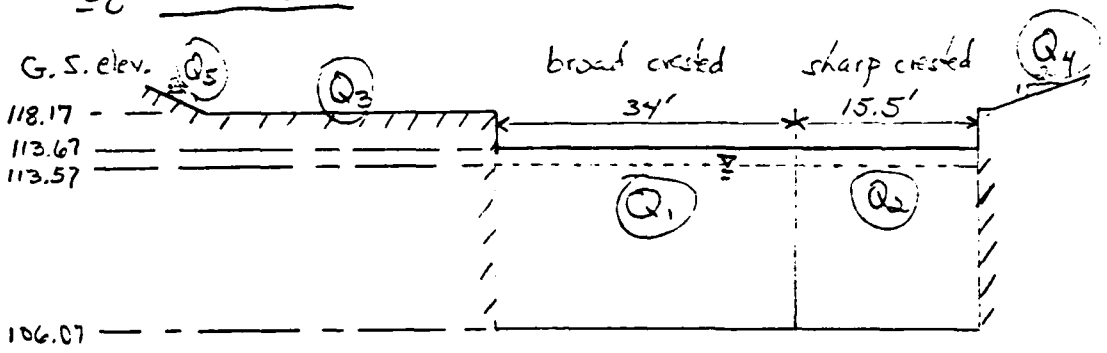
Test Flood = 7500 cfs


1 MILE
SANDOWN
DANVILLE
KINGSTON
EAST KINGSTON
HAMPSTEAD
NEWTON
North Danville
Coburn Hill
Philbrick Hill
French Hill
Sandown
Rock Rimmon Hill
Rock Rimmon State Forest
Camp Lincoln
Kingston State Park
Greenwood Pond
Sanborn Sch
Bakie Sch
Kingston
East Kingston
Great Pond
Halfmoon Pond
Long Pond
Cub Pond
Little Cub Pond
Punch Pond
Diamond Pond
Danville
Bacon Sch
West Kingston
Powwow River
Powwow Pond
Angle Pond
South Danville
Bartlett
Cedar Swamp Pond
East Hampstead
Country Pond
Wash Pond
Baglett Grove
South Kingston
Hampstead
Central Sch
Newton
Sargent Corners
Crane Crossing
Rowes Corner
Aspen Hill
Newton Junction
Willow Grove Cem
Old Town Cem
Hassiting Millpond
Hog Hill Pond
Pine Knoll
Sawmill
Swamp
Lily Pond
Phillips Pond
Shorrell Pond
Smith
Gravel Pit
Cem
Soldiers Cem
Pine Knoll Cem
Hadley Cem
Mill Hill Cem
Boy Scout Camp
Miser Hill
Hawkwood
Boston Road
Maine
Land
Telephone
Brook
River
13
D-3
NEW HAMPSHIRE
MASSACHUSETTS

Trickling Falls Dam (not to scale)




equivalent dam




Length of dam (minus the spillway length) = 200.5'

Width of dam = 55'

Length of spillways (broad) = 34'
(sharp) = 15.5'

Freeboard (Top elev. - spillway elev.) = 4.5'

Slopes: outside of dam 1:20

Trickling Falls Dam

$h=0$ at the spillway crest (elev. 113.67)

so:

when $h<0$ $\quad Q_T = Q_1+Q_2+Q_3+Q_4+Q_5 = 0$

when $0 \le h \le 4.5$ $\quad Q_1 = 3.0(34.0)(h)^{3/2}$

$Q_2 = 3.33(15.5)(h)^{3/2}$

$Q_3 = Q_4 = Q_5 = 0$

when $h \ge 4.5$ $\quad Q_1 = 3.0(34.0)(h)^{3/2}$

$Q_2 = 3.33(15.5)(h)^{3/2}$

$Q_3 = 2.8(200.5)(h-4.5)^{3/2}$

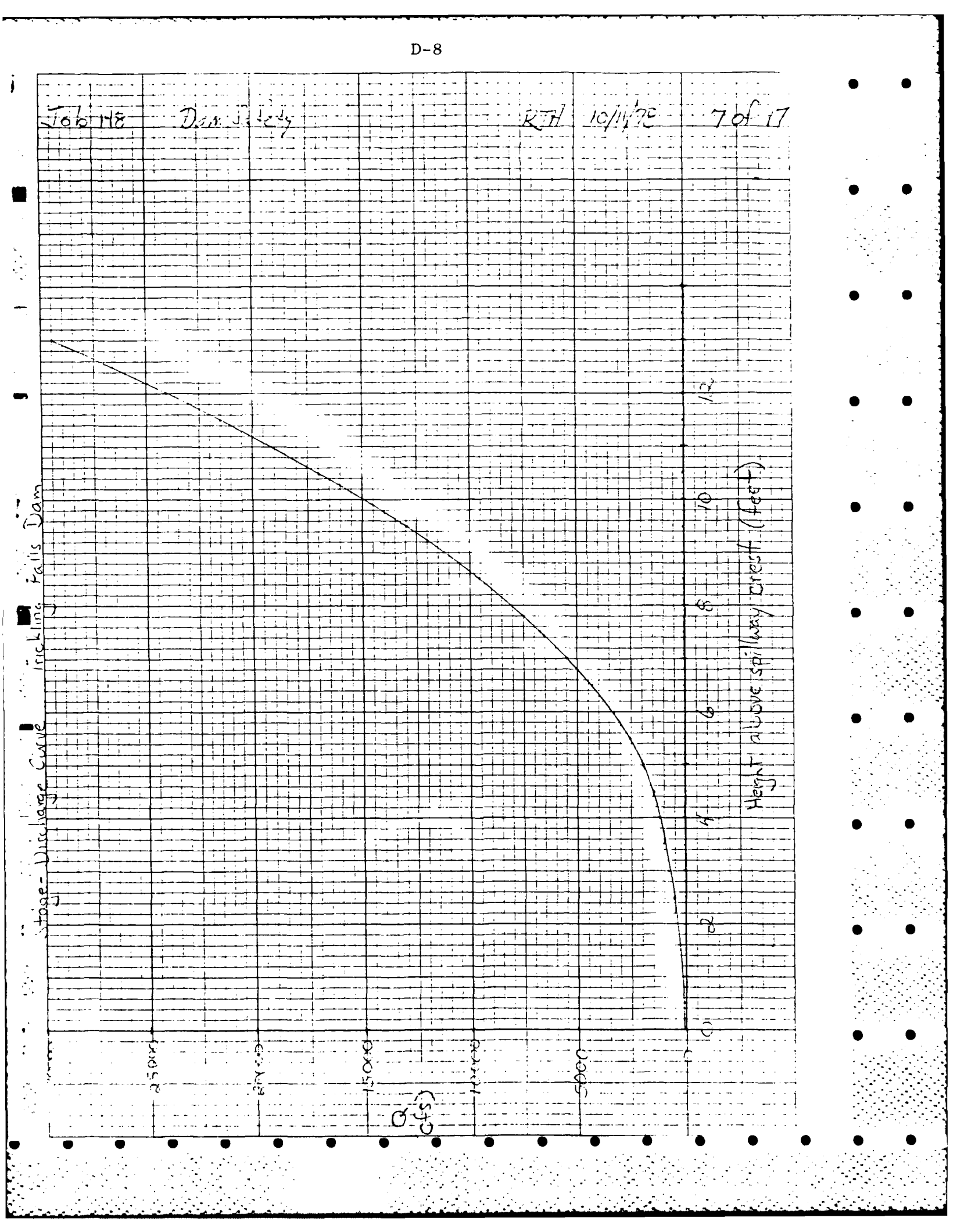
$Q_4 = Q_5 = 2.8(20(h-4.5)(.5(h-4.5))^{3/2}$

A listing of and output from a program (using the above equations) that calculate a head-discharge relationship follow. These calculations assume the stop logs are in place to elevation 113.67!

```
100 REMARK: DISCHARGE CALCULATION FOR TRICKLING FALLS DAM -
105 REMARK: STOPLOGS TO ELEVATION 113.67
110 PAGE
120 E=1.5
130 PRINT "DISCHARGE FROM TRICKLING FALLS DAM - STOPLOGS IN PLACE"
140 PRINT USING 150:
150 IMAGE // 2T"HEAD"30T"DISCHARGE"
160 PRINT USING 170:
170 IMAGE 1T"(FEET)"32T"(CFS)"
180 PRINT USING 190:
190 IMAGE 10T"TOTAL  SPILLWAY  SPILLWAY   DAM CREST   SIDE SLOPES"
192 PRINT USING 193:
193 IMAGE 10T"         (broad)   (sharp)   "
194 PRINT "  "
200 REMARK:      Q4 is flow over the side slopes, Q3 is flow over the
210 REMARK: dam crest, Q2 is flow over the sharp crested spillway, and
220 REMARK: Q1 is the flow over the broad crested spillway.
230 FOR H=0 TO 13 STEP 0.5
240 Q1=3*34*H↑E
250 Q2=3.33*15.5*H↑E
260 Q3=0
270 Q4=0
280 Q5=0
290 IF H<=4.5 THEN 330
300 Q4=2.8*(20*(H-4.5))*(0.5*(H-4.5))↑E
310 Q4=Q4*2
320 Q3=2.8*200.5*(H-4.5)↑E
330 Q5=Q1+Q2+Q3+Q4
340 PRINT USING 350:H,Q5,Q1,Q2,Q3,Q4
350 IMAGE 1T,2D.2D,9D,8D,10D,11D,13D
360 NEXT H
370 END
```

## DISCHARGE FROM TRICKLING FALLS DAM - STOPLOGS IN PLACE

| HEAD (FEET) | DISCHARGE (CFS) TOTAL | SPILLWAY (broad) | SPILLWAY (sharp) | DAM CREST | SIDE SLOPES |
|---|---|---|---|---|---|
| 0.00 | 0 | 0 | 0 | 0 | 0 |
| 0.50 | 54 | 36 | 18 | 0 | 0 |
| 1.00 | 154 | 102 | 52 | 0 | 0 |
| 1.50 | 282 | 187 | 95 | 0 | 0 |
| 2.00 | 434 | 288 | 146 | 0 | 0 |
| 2.50 | 607 | 403 | 204 | 0 | 0 |
| 3.00 | 798 | 530 | 268 | 0 | 0 |
| 3.50 | 1006 | 668 | 338 | 0 | 0 |
| 4.00 | 1229 | 816 | 413 | 0 | 0 |
| 4.50 | 1466 | 974 | 493 | 0 | 0 |
| 5.00 | 1923 | 1140 | 577 | 198 | 7 |
| 5.50 | 2582 | 1316 | 666 | 561 | 40 |
| 6.00 | 3398 | 1499 | 759 | 1031 | 109 |
| 6.50 | 4358 | 1690 | 855 | 1588 | 224 |
| 7.00 | 5455 | 1889 | 956 | 2219 | 391 |
| 7.50 | 6690 | 2095 | 1060 | 2917 | 617 |
| 8.00 | 8059 | 2308 | 1168 | 3676 | 907 |
| 8.50 | 9565 | 2528 | 1279 | 4491 | 1267 |
| 9.00 | 11208 | 2754 | 1394 | 5359 | 1701 |
| 9.50 | 12988 | 2987 | 1511 | 6277 | 2214 |
| 10.00 | 14908 | 3226 | 1632 | 7241 | 2809 |
| 10.50 | 16969 | 3470 | 1756 | 8251 | 3492 |
| 11.00 | 19173 | 3721 | 1883 | 9303 | 4265 |
| 11.50 | 21522 | 3978 | 2013 | 10397 | 5134 |
| 12.00 | 24017 | 4240 | 2146 | 11531 | 6100 |
| 12.50 | 26660 | 4508 | 2281 | 12703 | 7168 |
| 13.00 | 29454 | 4781 | 2419 | 13912 | 8341 |


Job 148 Dam Safety RTH 10/11/78 7 of 17
Stage-Discharge Curve Freckling Falls Dam
Height above spillway crest (feet)
0
2
4
6
8
10
12
Q (cfs)
0
500
1000
1500
2000
2500

Trickling Falls Dam

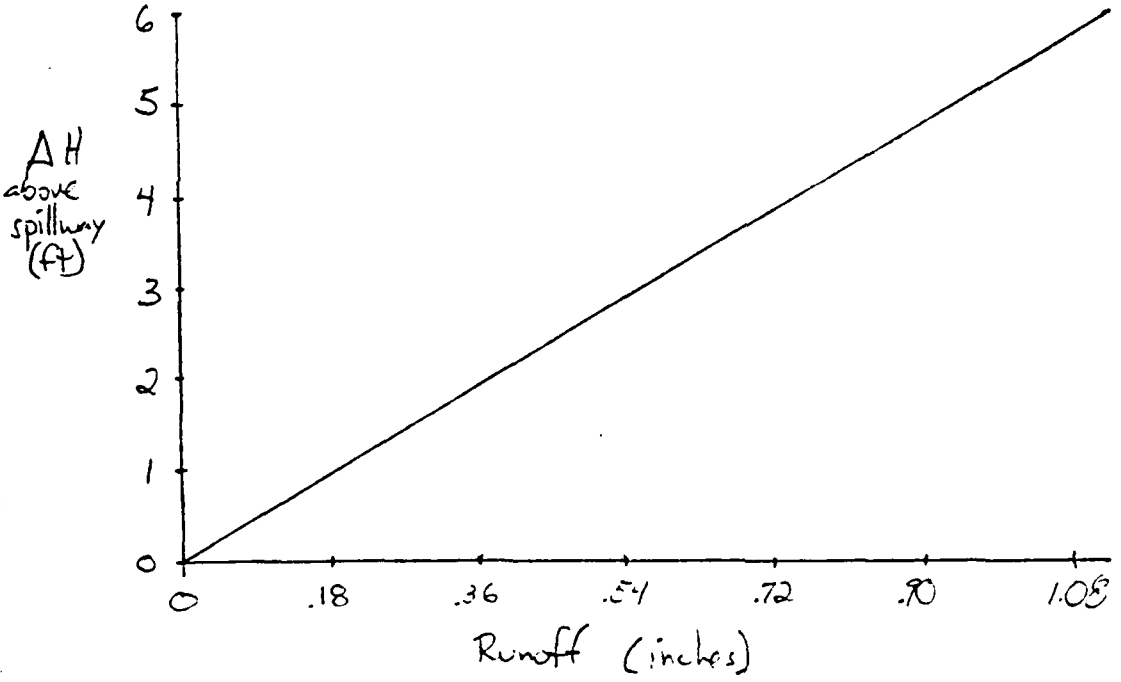
Storage-Stage Relationship:

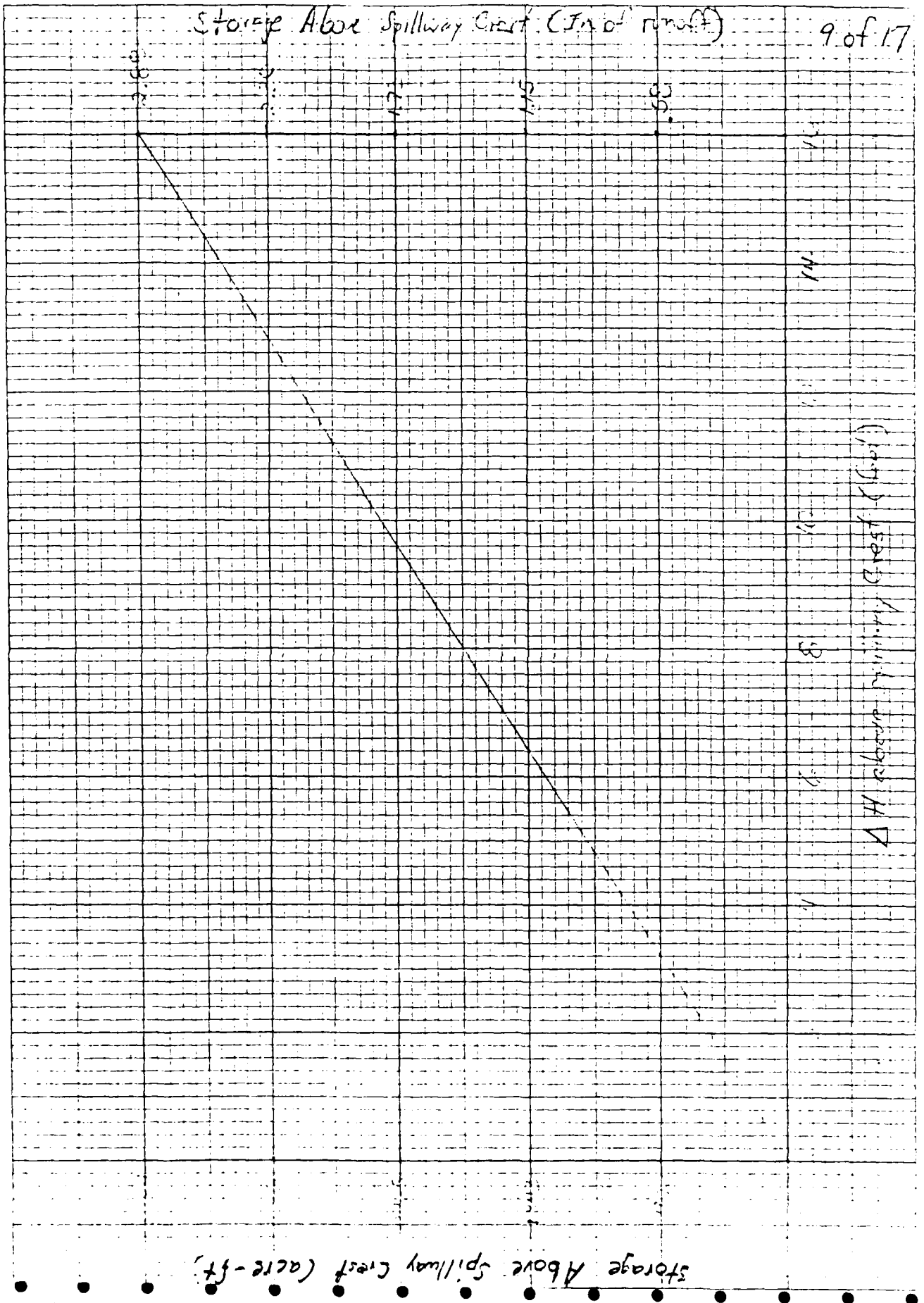
Surface Area of pond (normal) = 288 acres
and the Drainage area = 30.6 sq. mi.

So 1" of runoff produces a marginal increase in water elevation of: $\frac{(1\text{ inch runoff})(30.6\ \text{mi}^2)(640\ \text{acres/mi}^2)}{288\ \text{acres}} = 68''$

So assuming that the surface area is constant

1 foot of rise $\Rightarrow \frac{12''}{68''} = 0.18''$ of runoff




Storage Above Spillway Crest (In of runoff)
9 of 17
ΔH above Spillway Crest (Feet)
Storage Above Spillway Crest (acre-ft)

Trickling Falls Dam

Reduction in Flow Due to Storage:
- Assume a total storm volume equivalent to 6.5" of runoff
- To attenuate the peak discharge (due to storage) the COE suggested methodology is used with additional iterations:

$$Q_{P_2} = Q_{P_1}\left(1 - \frac{STOR}{6.5}\right)$$

① $Q_{P_1} = 7500$ cfs → yields head of 7.80 ft.
runoff = 7.8(.18) = 1.40 inches

$$Q_{P_2} = 7500\left(1 - \frac{1.40}{6.5}\right) = 5885 \text{ cfs}$$

② $Q_{P_2} = 5885$ cfs → yields $h = 7.17$ ft.
runoff = 7.17(.18) = 1.29 inches

$$Q_{P_3} = 7500\left(1 - \frac{1.29}{6.5}\right) = 6010 \text{ cfs}$$

③ $Q_{P_3} = 6010$ cfs → yields $h = 7.22$ ft.
runoff = (7.22)(.18) = 1.30 inches

$$Q_{P_4} = 7500\left(1 - \frac{1.30}{6.5}\right) = 6000 \text{ cfs}$$

④ $Q_{P_4} = 6000$ → yields $h = 7.22$ ft

⑤ $h_{avg} = 7.22$ ft
runoff = 7.22(0.18) = 1.30 in.

$$Q_{P_f} = 7500\left(1 - \frac{1.30}{6.5}\right) = \underline{6000 \text{ cfs}}$$

Final attenuated flow = 6000 cfs

flood depth = 7.2 ft above the ceiling
= 2.7 ft above dam crest

Trickling Falls Dam

Calculations of Estimated Downstream Dam Failure Flood Stages - Based upon COE "Rule of Thumb" Guidance, April 1978

Step 1 - Reservoir Storage at Time of Failure

Assume failure occurs when water level is at dam crest (4.5 feet above the spillway)

Storage = Normal + Surcharge = 400 (acre-ft) + (4.5 ft)(285 acres)

= 1696 acre-ft

Step 2 - Peak Failure Outflow

$$Q_{P_1} = 8/27\, W_b \sqrt{g}\, y_o^{3/2}$$

$W_b$ = breach width < 40% of dam length
< 0.4(250 ft) = 100 ft
$W_b$ = use 60 ft

$g$ = 32.2 ft/sec$^2$

$y_o$ = Pond ~~Height~~ depth at failure = 118.17 - 106.07 = 12.1 ft

$$Q_{P_1} = 8/27 (60) \sqrt{32.2} (12.1)^{3/2}$$

$Q_{P_1}$ = 4246 cfs → use 4300 cfs

Step 3 - Develop Stage - Discharge Routing for Downstream Reaches

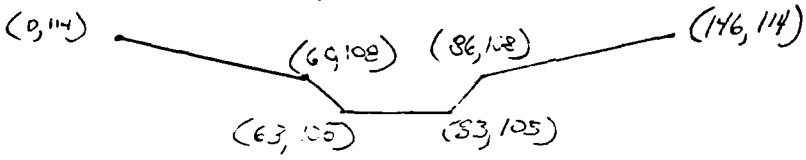
- Downstream of the dam there are essentially three stream reaches. The first is 200 feet long with a well defined channel (about 20' wide), ending at a bridge which has a 17' by 7' opening. Downstream of the bridge the channel remains well defined for about 500' (Reach 2), and then opens into a swamp about 1000' wide (Reach 3).

Trickling Falls Dam

The following reaches are derived from the USGS topo maps and field information:

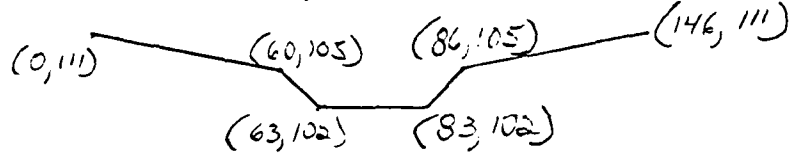
Reach 1: - Dam to Bridge -

$L = 200$ ft.
$S = 2/200 = 0.01$
$n = 0.04$



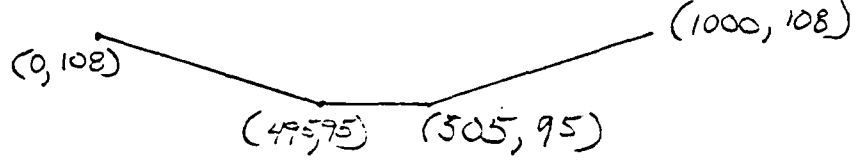

Reach 2: - Bridge to Swamp -

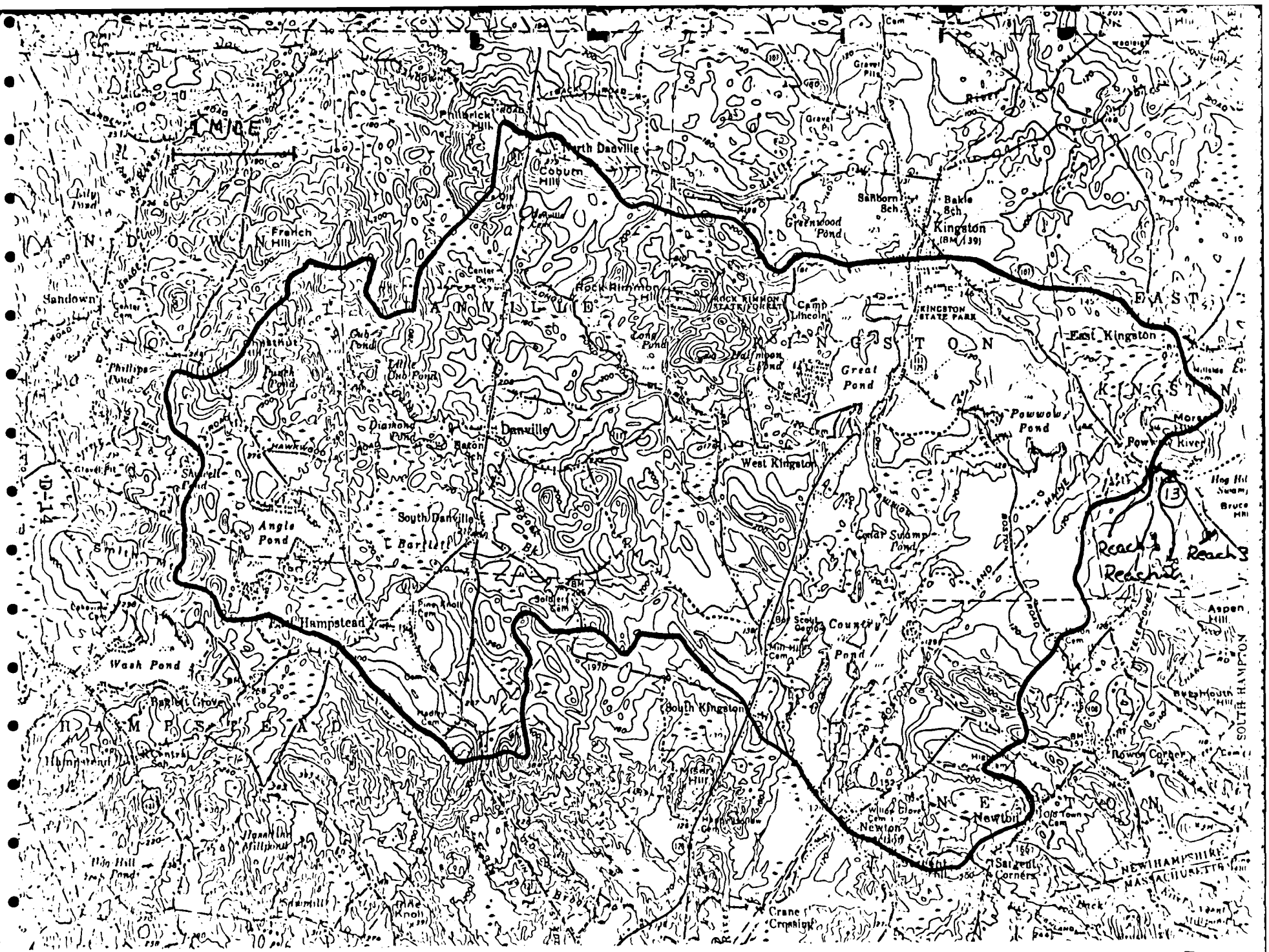
$L = 500$ feet
$S = 0.01$
$n = 0.04$




Reach 3: Swamp

$L = 10000$ ft
$S = 0.005$
$n = 0.1$




1 MILE
North Danville
Coburn Hill
Philbrick Hill
French Hill
Sandown
Phillips Pond
Rock Rimmon Hill
Rock Rimmon State Forest
Camp Lincoln
Kingston State Park
Kingston
Greenwood Pond
Sanborn Sch
Bakle Sch
East Kingston
Great Pond
Powwow Pond
Powwow River
Danville
Baton Sch
West Kingston
South Danville
Angle Pond
Bartlett
Hampstead
Wash Pond
Country Pond
South Kingston
Newton
Newton Junction
Sargent Corners
Crane Crossing
Aspen Hill
Rowes Corner
Reach 1
Reach 2
Reach 3
13
D-14
NEW HAMPSHIRE
MASSACHUSETTS
SOUTH HAMPTON

| DEPTH | ELEV | AREA | WPER | HYD-R | AR2/3 | Q |
|---|---|---|---|---|---|---|
| 0.0 | 105.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.5 | 105.5 | 10.3 | 21.4 | 0.5 | 6.3 | 23.4 |
| 1.0 | 106.0 | 21.0 | 22.8 | 0.9 | 19.9 | 74.0 |
| 1.5 | 106.5 | 32.3 | 24.2 | 1.3 | 39.0 | 145.3 |
| 2.0 | 107.0 | 44.0 | 25.7 | 1.7 | 63.1 | 234.9 |
| 2.5 | 107.5 | 56.3 | 27.1 | 2.1 | 91.6 | 341.3 |
| 3.0 | 108.0 | 69.0 | 28.5 | 2.4 | 124.5 | 463.7 |
| 3.5 | 108.5 | 84.5 | 38.5 | 2.2 | 142.7 | 531.4 |
| 4.0 | 109.0 | 105.0 | 48.6 | 2.2 | 175.6 | 654.0 |
| 4.5 | 109.5 | 130.5 | 58.6 | 2.2 | 222.5 | 828.9 |
| 5.0 | 110.0 | 161.0 | 68.7 | 2.3 | 284.2 | 1058.6 |
| 5.5 | 110.5 | 196.5 | 78.7 | 2.5 | 361.7 | 1347.2 |
| 6.0 | 111.0 | 237.0 | 88.8 | 2.7 | 456.2 | 1699.4 |
| 6.5 | 111.5 | 282.5 | 98.8 | 2.9 | 569.2 | 2120.2 |
| 7.0 | 112.0 | 333.0 | 108.9 | 3.1 | 701.9 | 2614.5 |
| 7.5 | 112.5 | 388.5 | 118.9 | 3.3 | 855.6 | 3187.2 |
| 8.0 | 113.0 | 449.0 | 129.0 | 3.5 | 1031.7 | 3843.2 |
| 8.5 | 113.5 | 514.5 | 139.0 | 3.7 | 1231.5 | 4587.2 |
| 9.0 | 114.0 | 585.0 | 149.1 | 3.9 | 1456.0 | 5423.7 |

REACH 1 AND 2

TRICKLING FALLS DAM

| DEPTH | ELEV | AREA | WPER | HYD-R | AR2/3 | Q |
|---|---|---|---|---|---|---|
| 0.0 | 95.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 0.5 | 95.5 | 14.5 | 48.1 | 0.3 | 6.5 | 6.9 |
| 1.0 | 96.0 | 48.1 | 86.2 | 0.6 | 32.6 | 34.3 |
| 1.5 | 96.5 | 100.7 | 124.3 | 0.8 | 87.5 | 92.2 |
| 2.0 | 97.0 | 172.3 | 162.4 | 1.1 | 179.3 | 188.9 |
| 2.5 | 97.5 | 263.0 | 200.5 | 1.3 | 315.2 | 332.1 |
| 3.0 | 98.0 | 372.7 | 238.5 | 1.6 | 501.9 | 528.8 |
| 3.5 | 98.5 | 501.4 | 276.6 | 1.8 | 745.6 | 785.6 |
| 4.0 | 99.0 | 649.2 | 314.7 | 2.1 | 1052.3 | 1108.7 |
| 4.5 | 99.5 | 816.1 | 352.8 | 2.3 | 1427.7 | 1504.2 |
| 5.0 | 100.0 | 1001.9 | 390.9 | 2.6 | 1877.1 | 1977.7 |
| 5.5 | 100.5 | 1206.8 | 429.0 | 2.8 | 2405.8 | 2534.7 |
| 6.0 | 101.0 | 1430.8 | 467.1 | 3.1 | 3018.9 | 3180.7 |
| 6.5 | 101.5 | 1673.8 | 505.2 | 3.3 | 3721.3 | 3920.8 |
| 7.0 | 102.0 | 1935.8 | 543.3 | 3.6 | 4517.9 | 4760.0 |
| 7.5 | 102.5 | 2216.8 | 581.4 | 3.8 | 5413.2 | 5703.3 |
| 8.0 | 103.0 | 2516.9 | 619.4 | 4.1 | 6411.9 | 6755.5 |
| 8.5 | 103.5 | 2836.1 | 657.5 | 4.3 | 7518.4 | 7921.3 |
| 9.0 | 104.0 | 3174.2 | 695.6 | 4.6 | 8737.1 | 9205.3 |
| 9.5 | 104.5 | 3531.4 | 733.7 | 4.8 | 10072.4 | 10612.1 |
| 10.0 | 105.0 | 3907.7 | 771.8 | 5.1 | 11528.3 | 12146.1 |
| 10.5 | 105.5 | 4303.0 | 809.9 | 5.3 | 13109.1 | 13811.6 |
| 11.0 | 106.0 | 4717.3 | 848.0 | 5.6 | 14818.9 | 15613.0 |
| 11.5 | 106.5 | 5150.7 | 886.1 | 5.8 | 16661.6 | 17554.4 |
| 12.0 | 107.0 | 5603.1 | 924.2 | 6.1 | 18641.2 | 19640.1 |
| 12.5 | 107.5 | 6074.5 | 962.3 | 6.3 | 20761.6 | 21874.2 |
| 13.0 | 108.0 | 6565.0 | 1000.3 | 6.6 | 23026.7 | 24260.7 |

REACH 3

TRICKLING FALLS DAM

Job HE Dam Safety RJH 10/17/78 16 of 17

Trickling Falls Dam

Step 4: Calculate Downstream Attenuation

Reach 1 - $Q_{p_1} = 4300$ cfs $\longrightarrow h_1 = 8.31$ ft
$\hookrightarrow A_1 = 490$ ft²

$V_1 = \frac{[illegible]}{43560} = 2.25$ acre-ft

$Q_{p_{DT}} = 4300\left(1 - \frac{2.25}{16.96}\right) \approx 4300$ cfs no attenuation

There is no attenuation by the standard method, however the bridge culvert controls the flow rate to the next reach. The culvert is 17' by 7' and it is assumed the water depth in the reach is 12.1 ft (same ht. as dam). This means that the culvert is submerged, and the roadway (7.8 ft above the culvert invert) is overtopped by 2.3 ft. The width of overtopping is ~~the~~ assumed to be 60 ft (same as breach width). The culvert capacity is computed using FHWA nomographs and the flow over the roadway is estimated using the equation for flow over a broadcrested weir:

Roadway flow = $Q_o = 2.8 (\omega_o)(h_o)^{3/2}$

$\omega_o = 60$ ft

$h_o = 2.3$ ft

$Q_o = 2.8 (60)(2.3)^{3/2}$

$Q_o = \underline{586}$ cfs

Culvert flow - culvert = 7 ft in height

water depth = 12 ft

ratio (depth/height) = 1.73

from the nomograph → $Q_c = [illegible]$ cfs/ft (17 ft)

$Q_c = 1445$ cfs

$Q_1 = \underline{2030}$ cfs

Therefore the peak flow passed to reach 2 is 2030 cfs.

Trickling Falls Dam

Reach 2:

$Q_{P_1} = 2030$ cfs → $h_1 = 6.35'$, $A_1 = 273$ ft²

$V_1 = \frac{500(273)}{43560} = 3.13$ acre-ft

$Q_{P_2} = 2030\left(1 - \frac{3.13}{1696}\right) = 2027$ cfs → $h_2 = 6.35'$, $A_2 = 273$ ft²

$Q_{P_2} = 2027$ cfs

Reach 3:

$Q_{P_1} = 2027$ cfs → $h_2 = 5.04'$, $A_2 = 1020$ ft²

$V_1 = \frac{10000(1020)}{43560} = 234.2$ acre-ft

$Q_{P_{2T}} = 2027\left(1 - \frac{234.2}{1696}\right) = 1747$ cfs → $h_2 = 4.76'$, $A_2 = 911$ ft²

$V_2 = \frac{10000(911)}{43560} = 209.2$ acre-ft

$Q_{P_{3T}} = 2027\left(1 - \frac{209.2}{1696}\right) = 1777$ cfs → $h_3 = 4.79'$, $A_3 = 923$ ft

$V_3 = \frac{10000(923)}{43560} = 211.9$ acre-ft

$V_{avg} = V_2 + V_3/2 = 210.55$ acre-ft

$Q_{P_3} = 2027\left(1 - \frac{210.55}{1696}\right) = \underline{1775 \text{ cfs}} \rightarrow \underline{h = 4.79'}$

# APPENDIX E

## INFORMATION AS CONTAINED IN

## THE NATIONAL INVENTORY OF DAMS

# INVENTORY OF DAMS IN THE UNITED STATES

| STATE | IDENTITY NUMBER | CONGR DIST. | NAME | LATITUDE (NORTH) | LONGITUDE (WEST) | REPORT DATE DAY | MO | YR |
|---|---|---|---|---|---|---|---|---|
| NH | [illegible] | | CHICKLING FALLS DAM | 4254.5 | 7101.1 | 27 | NOV | 78 |

| POPULAR NAME | NAME OF IMPOUNDMENT |
|---|---|
| | POWWOW POND |

| RIVER OR STREAM | NEAREST DOWNSTREAM CITY–TOWN–VILLAGE | DIST FROM DAM (MI.) | POPULATION |
|---|---|---|---|
| [illegible] RIVER | SOUTH HAMPTON | 2 | 575 |

| TYPE OF DAM | YEAR COMPLETED | PURPOSES | STRUCTURAL HEIGHT (FT.) | HYDRAULIC HEIGHT (FT.) | IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.) | IMPOUNDING CAPACITIES NORMAL (ACRE-FT.) | DIST | OWN | FED R | PRV/FED | SCS A | VER/DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | 1940 | R | 12 | 12 | 1700 | 400 | NED | N | N | N | N | 13DEC78 |

| REMARKS |
|---|
| |

| DESIGN | SPILLWAY TYPE | SPILLWAY WIDTH | MAXIMUM DISCHARGE (FT.) | VOLUME OF DAM (CY) | POWER CAPACITY INSTALLED (MW) | POWER CAPACITY PROPOSED (MW) | NAVIGATION LOCKS NO. | LOCK 1 LENGTH (FT.) | LOCK 1 WIDTH (FT.) | LOCK 2 LENGTH (FT.) | LOCK 2 WIDTH (FT.) | LOCK 3 LENGTH (FT.) | LOCK 3 WIDTH (FT.) | LOCK 4 LENGTH (FT.) | LOCK 4 WIDTH (FT.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | 975 | | | | | | | | | | | | |

| OWNER | ENGINEERING BY | CONSTRUCTION BY |
|---|---|---|
| [illegible] | NH WAT RES BD | NH WAT RES BD |

| REGULATORY AGENCY | | | |
|---|---|---|---|
| DESIGN | CONSTRUCTION | OPERATION | MAINTENANCE |
| [illegible] | NONE | NONE | NONE |

| INSPECTION BY | INSPECTION DATE DAY | MO | YR | AUTHORITY FOR INSPECTION |
|---|---|---|---|---|
| [illegible] DINNICLIFF + ASSOC | 21 | SEP | 78 | PUBLIC LAW 92-367 |

| REMARKS |
|---|
| |

REPRODUCED AT THE GOVERNMENT EXPENSE

# END

# FILMED

8-85

# DTIC